

Colour Photography and Film:

**Sharing knowledge of analysis, preservation,
conservation, migration of analogue and digital materials**

2021



Edited by Barbara Cattaneo, Marcello Picollo, Filippo Cherubini and Veronica Marchiafava

www.gruppodelcolore.org

Research Culture And Science Books series - Vol. 001



Colour Photography and Film: Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials – 2021

Edited by Barbara Cattaneo, Marcello Picollo, Filippo Cherubini and Veronica Marchiafava



www.gruppodelcolore.org

Regular Member
AIC Association Internationale de la Couleur

Colour Photography and Film:

Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials

RESEARCH CULTURE AND SCIENCE BOOKS (RCASB) series Vol. 001

ISSN: 2785-115X

www.rcasb.eu

RCASB licensing terms: books published on the RCASB series are open access books, distributed under the terms and conditions of the Creative Commons Attribution License (CC BY). You are free to share (copy and redistribute the material in any medium or format) and adapt (remix, transform, and build upon the material for any purpose, even commercially, under the following terms: you must give appropriate credit to authors, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use; you may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. The authors keep the rights to further publish their contents where they want and can archive pre-print and post-print or the publisher's version of the PDF of their books with no embargo period.

RCASB peer review process: all books submitted to the Research Culture And Science Book series are peer-reviewed according to the following procedure:

First review level: the series Editors evaluate the book to determine if the topic and content are of interest to the RCASB series. Once the book has passed this preliminary review, the series Editors select several reviewers from the Editorial Board based on their expertise in a particular subject area or topic.

Second review level: each book is reviewed by two or three reviewers with a blind peer-review process where the reviewers are kept anonymous. Reviewers are asked to evaluate the book proposal based on the following criteria:

- Originality
- Relevance to RCASB series multidisciplinary approach
- Technical/Cultural merit and/or validity
- Soundness of methodology
- Completeness of the reported work
- Conclusions supported by the data
- Correct acknowledgment of the work of others through references
- Effectiveness of the manuscript (organization and writing)
- Clarity of tables, graphs, and illustrations
- Importance to multidisciplinary researchers
- Relevance to multidisciplinary practices

If the book is accepted with revisions by the reviewers, the author(s) are asked to improve the book according to the suggestions provided. The revised book proposal will then be submitted for further review. After collecting the reviewers' reports, the series Editors decide on the book's acceptability for publication.

Book Title:

Colour Photography and Film: Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials – 2021

Edited by: Barbara Cattaneo, Marcello Picollo, Filippo Cherubini and Veronica Marchiafava

DOI: 10.23738/RCASB.001

ISBN 978-88-99513-14-6

© Copyright 2021 by Gruppo del Colore – Associazione Italiana Colore

Piazza C. Caneva, 4

20154 Milano

C.F. 97619430156

P.IVA: 09003610962

www.gruppodelcolore.it

e-mail: segreteria@gruppodelcolore.org

Translation rights, electronic storage, reproduction
and total or partial adaptation with any means reserved for all countries.

Published by Gruppo del Colore – Associazione Italiana Colore in the months of July/August 2021

Colour Photography and Film:

Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials

Colour Photography and Film: Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials – Conference Proceedings

March 29-30, 2021

Organised by Gruppo del Colore – Associazione Italiana Colore

*Under the patronage of
Opificio delle Pietre Dure
and*

Institute of Applied Physics “Nello Carrara” of the Italian Research Council (IFAC-CNR)

Organizing Committee

Barbara Cattaneo
Marcello Picollo
Andrea Siniscalco
Veronica Marchiafava
Filippo Cherubini

Programme Committee

Barbara Cattaneo
Marcello Picollo

Organizing Secretariat

Veronica Marchiafava, Associazione Italiana Colore

Scientific Committee – Peer review

Barbara Cattaneo	Opificio delle Pietre Dure (OPD), Florence (Italy)
Costanza Cucci	Istituto di Fisica Applicata “Nello Carrara” of the Consiglio Nazionale delle Ricerche (IFAC-CNR), Florence (Italy)
Giovanna Fossati	Eye Filmmuseum / University of Amsterdam, Amsterdam (NL)
Bertrand Lavédrine	Centre de Recherche sur la Conservation (CRC), Paris (France)
Tom Learner	Getty Conservation Institute, Los Angeles (USA)
Austin Nevin	Courtauld Institute of Art, London (UK)
Sylvie Pénichon	The Art Institute of Chicago (AIC), Chicago (USA)
Roberta Piantavigna	San Francisco Museum of Modern Art, San Francisco (USA)
Marcello Picollo	Istituto di Fisica Applicata “Nello Carrara” of the Consiglio Nazionale delle Ricerche (IFAC-CNR), Florence (Italy)
Katrin Pietsch	University of Amsterdam (UvA), Amsterdam (The Netherlands)
Alice Plutino	Università degli Studi di Milano, Milan (Italy)
Alessandro Rizzi	Università degli Studi di Milano, Milan (Italy)
Yoko Shiraiwa	Shiraiwa Conservation Studio, Tokyo (Japan)
Giorgio Trumpy	University of Zurich, Zurich (Switzerland)

Foreword

The Gruppo del Colore - Associazione Italiana Colore is a scientific and cultural non-profit organization with a multidisciplinary approach. Its aims are to promote science and culture of Color and Light, to spread scientific, technological, cultural and applicative knowledge about the cited disciplines, and to support matters of common interest between members in national and international contexts. In 2020, the Association added another instrument of cultural dissemination, in the form of a diamond open access book series, The Research Culture And Science Book series (RCASB), which is freely available to everyone.

The focus and scope of the series is multidisciplinary as RCASB publishes scientific books on specific fields. The aim of the book series is to encourage scientists, scholars, researchers and professionals to publish their experimental results and theoretical work in a comprehensive way, thus providing a forum for the exchange and sharing of scientific knowledge.

Since this volume is the first of many others to come, it was considered appropriate to begin with a very current topic, which is of vital importance for the study and conservation of contemporary artistic artefacts, such as color photographic and cinematographic materials, in both format analogue and digital. This volume consists of a collection of essays derived from presentations given at the International Conference on "Color Photography and Cinema: Sharing Knowledge of Analysis, Conservation, Conservation, Migration of 'analogue and digital materials" organized in March 2021 by the Gruppo del Colore - Italian Color Association in collaboration with the "Nello Carrara" Institute of Applied Physics of the National Research Council (IFAC-CNR) and the Opificio delle Pietre Dure (OPD).

This conference was a unique event as the first international convening in which these topics were treated together. As such, it was an opportunity for discussion at an international level on various topics related to furthering the knowledge of color photographic and cinematographic objects from a historical, material and conservation point of view. It is our hope that this volume will contribute to disseminating to a wide audience the various issues relating to the material and conservation knowledge of these materials and that it contributes to deepening sensitivity towards treating these materials in museum and archive collections.

Florence, August 2021

Marcello Picollo - President

Gruppo del Colore – Associazione Italiana Colore

Index

The Jos-Pe process in the Jacob Merkelbach collection at the Rijksmuseum in Amsterdam.....	8
<i>Laura Coversi</i>	
Interpreting 35mm chromogenic slide film: the Ed van der Elsken case-study.....	14
<i>Lénia Oliveira Fernandes</i>	
Truelight: from film to digital, 2000-2015.....	22
<i>Richard Kirk</i>	
The effects of finish coatings on ultraviolet and visible light stability of inkjet prints	29
<i>Ella Solomon</i>	
Photographic and Cinematographic Film Repository (FiRE): identification of films for digital restoration.....	37
<i>Arianna Crespi, Giulia Morabito, Alice Plutino, Alessandro Rizzi</i>	
Digitizing Archive Film: Image, Information and History.....	42
<i>Manuel Goetz</i>	
Towards a Standardised Terminology for Photographic Materials In The Netherlands.....	46
<i>Kayleigh van der Gulik, Magdalena Pilko, Martin Jürgens, Sanneke Stigter, Clara von Waldthausen</i>	
The Autumn Colours of Sound: Reading the Records of Old R2R Audio Tapes of the 70's.....	50
<i>Maja Kostadinovska</i>	
I've Just Seen a Face: Preserving Photographic Memories and Hope Following a Disaster	55
<i>Debra Hess Norris</i>	
Color on glass-about conservation and preservation projects of Crystoleum, Autochromes, Agfa Color Plates and Dufay/Dioptichrome Plate photographs (case studies).....	59
<i>Anna Sewryn</i>	
Digital Struggles: from Film Restoration to a Digital Historical-Critical Environment.....	67
<i>Serena Bellotti, Simone Venturini</i>	
The Flexichrome: visual examination and scientific analysis of an overlooked color photographic process.....	74
<i>Nayla Maaruf, Sylvie Pénichon, Maria Kokkori</i>	
Non-destructive Analysis of Hand-Colored photographs: A Case study on photographs dating back to the 19th century.....	76
<i>Emil Henin</i>	
deep-doLCE – A Deep Learning Approach for the Color Reconstruction of Digitized Lenticular Film.....	82
<i>Giorgio Trumpy, Stefano D'Aronco, Jan Kirk Wegner, Joakim Reuteler</i>	

In the face of the Typhoon 19: a report on salvaging the Kawasaki City Museum's photography and film collection.....	89
<i>Kanako Nakanishi, Kanako Nakano</i>	
Image Quality Metrics for Digital Film Restoration.....	93
<i>Majed Chambah</i>	
The long-term development of three-color Kodachrome. An odyssey from the additive to the subtractive method of color reproduction.....	100
<i>Nicolas Le Guern</i>	
Spliced, face-mounted inkjet print – one preservation solution for large format photographic artworks.....	108
<i>Markus Paul Müller, Ute Henniges</i>	
MOUNTING CHROMOGENIC PRINTS – one potential solution for the prevention of yellowing issues on photopaper.....	112
<i>Markus Paul Müller, Ute Henniges</i>	
Digitization of large-scale artwork with LED technology.....	114
<i>Markus Paul Müller, Raffael Pollak</i>	
Reference scan an objective way to document colors and surface changes in artworks... ..	116
<i>Markus Paul Müller, Sven Schönauer</i>	
eTDP- extended Technical Documentation of Photography.....	118
<i>Markus Paul Müller, Jessica Morhard</i>	
Conservation treatments for Autochrome plates: limits and possibilities.....	120
<i>Sara Brancato</i>	
Film Reconstruction and the Forensic Imagination in The Case of “Spedizione Franchetti nella Dancalia”.....	127
<i>Andrea Mariani, Serena Bellotti</i>	
Differentiating Chromogenic and Silver Dye Bleach Materials by UV Reflectance imaging.....	131
<i>Rahul Sharma</i>	
A long-term study of light-induced yellowish stain formation that may develop over time in chromogenic color prints and contemporary inkjet prints exposed to light on display and followed by storage in the dark: further investigations of the complex roles optical brighteners (OBAs) and Titanium Dioxide (TiO₂) play in the degradation of color and B&W photographic prints over time.....	132
<i>Henry Wilhelm, Effiba Armah, Ken Boydston, Richard Adams, Charles Wilhelm</i>	
The Teutloff Collection: a multidimensional conservation project in the Grand-Duchy of Luxembourg.....	139
<i>Anke Reitz, Francesca Vantellini</i>	
“Making the beautiful even more beautiful”: Luriki practice of hand tinting analogue photography in the late Soviet epoch.....	147
<i>Oleksandra Osadcha</i>	

Prokudin-Gorskii's technique of colour photography: colour separation, additive and pigment printing.....	151
<i>Nadezhda Stanulevich</i>	
The start of the rainbow: possibilities of color motion photography for the amateur.....	158
<i>Louisa Trott</i>	
The use of colour in early filmic images.....	164
<i>Annamaria Poli</i>	
The origin of the colours of the first colour photograph: a predominant absorption phenomenon....	170
<i>Victor de Seauve, Marie-Angélique Languille, Bertrand Lavédrine</i>	
Green and greener solvents in photographic conservation.....	174
<i>Barbara Cattaneo, Giulia Fraticelli</i>	
Preserving color and preserving knowledge. Notes on digitization and restoration of color in film....	179
<i>Daniela Currò, Marco Pagni Fontebuoni</i>	
“Ceci n'est pas un Polaroid”. The materials and colours of Paolo Gioli's work.....	184
<i>Sandra Maria Petrillo</i>	
A novel compact probe for gloss measurements on photographic films.....	193
<i>Giovanni Bianchini, Lorenzo Lisi, Barbara Cattaneo, Marcello Picollo</i>	
Multispectral capture of film colors with LEDs.....	195
<i>Giorgio Trumpy, Jon Y. Hardeberg, Sony George, Barbara Flueckiger</i>	
Observation on preservation issues for contemporary photography artworks.....	199
<i>Roberta Piantavigna</i>	
Preserving the process knowledge of dye transfer printing.....	204
<i>Tess Hamilton, Nora Kennedy</i>	
The Lippmann Plate at the Fondazione Scienza e Tecnica in Florence.....	206
<i>Anna Giatti</i>	
Re-makeable Art and the digitally constructed image: case study of Geoff Kleem's wallpaper installation.....	209
<i>Analiese Treacy, Asti Sherring</i>	
Hyperspectral Imaging applied to the study of negative and positive films.....	217
<i>Marcello Picollo, Costanza Cucci, Andrea Casini, Lorenzo Stefani</i>	
BRITTLE MEMORIES. Case study of a broken photographic crystoleum.....	220
<i>Viviana Goggi, Martina Trento</i>	

The Jos-Pe process in the Jacob Merkelbach collection at the Rijksmuseum in Amsterdam

Laura Covarsi

Rijksmuseum, Amsterdam (The Netherlands)

lcovarsi@gmail.com

Abstract

The Rijksmuseum in Amsterdam holds a collection of 208 photographs from the Merkelbach Studio (1907-1961 in Amsterdam). At least 28 of them were made with the Jos-Pe technique, which was invented in Hamburg in 1924 and remained in use for 20 years. This dye imbibition process is part of the early history of commercial color photography. This research project begun with the characterization and visual examination of Jos-Pe prints on paper and three-color printing matrices on glass that are part of the Rijksmuseum's Merkelbach collection. The Rijksmuseum Jos-Pe prints and plates, as well as (aged) mock-ups were analyzed with different techniques: specular light, UV fluorescence, microscopy, XRF and liquid chromatography UPLC. A cross section obtained from an unexposed Jos-Pe paper made it possible to determine the prints' structure: a paper coated with a thin layer of barium sulfate, topped with a thin layer of gelatin. The analyzed glass plates revealed the use of dyes such as carmine, Induline Blue and Dianil Yellow 2R. Fading tests performed on mock-ups made of the red dye showed a Blue Wool Standard (BWS) lightfastness of 1-2. The fading tests of the other two dyes weren't performed. The specialized literature points out the lightfastness of the blue dye as 4 and 2-3 BWS for the yellow dye.

Keywords: Jos-Pe, Jacob Merkelbach, Dye-imbibition, Rijksmuseum, Subtractive Color Photography

Introduction

The Merkelbach collection, held at the Rijksmuseum in Amsterdam, offers an interesting corpus for studying the evolution and industry of photographic processes, with 13 different photographic processes the collection presents a very good example of the commercial photography used those days, between the 1920's and 1940's. The Jos-Pe prints in the collection are probably the most interesting objects in this group of photographs. The general lack of technical data on the process and the materials creates challenges for the conservation of these photographs. The objective of the research carried out in 2018 and 2019 was to study the material components of the prints and to examine the sensitivity of the image-forming dyes to factors such as light and oxygen, in order to evaluate exposure levels in exhibitions and loans.

Jacob Merkelbach and the Studio Merkelbach

Jacob Merkelbach (1877-1942) opened his studio in Amsterdam in 1913. It was located in a fashion house, on the fifth floor of the luxurious Hirsch & Cie. building. He worked mainly on commercial portraits, and his clients came from the high society of Amsterdam. Merkelbach also worked for theatre and dance world. It was one of the most important studios in Amsterdam in the period between the wars. Jacob Merkelbach died in 1942 and his daughter Mies continued the business until the 1960's, when the studio was permanently closed¹.

¹ Veen, A., Geusau, S., Banning, N., Heuvel, M. and Oort, T., 2013. *Fotostudio Merkelbach 1913-1969*. 1st ed. Amsterdam: Uitgeverij Komma.

During the last years, Mies Merkelbach sold the remaining collection (negatives and prints) to different buyers and institutions. In that period, the collector Bert Hartkamp bought a group of 200 prints on paper, a group that later became part of the Rijksmuseum Collection.

The Jos-Pe process

Jos-Pe is the name of a photographic process marketed by a company of the same name, in Hamburg, Germany, and active from 1924 to 1943, when a bomb destroyed the factory on the 25th of July. The process takes the name from Josef-Peter Walker, who ran the factory from 1924 until 1930. From 1934 until 1943, the business was run by one of the clients, Franz Vollmer.²

This technique is included in the group of the dye imbibition processes, together with other processes such as Sanger-Shepherd, Pinatype or Kodak Dye Transfer. It is a subtractive three-color process in which the print is made with three relief printing plates, blue, red and yellow, made from three color separation negatives³. The process relies on the capacity of gelatin to absorb or release dyes when in contact with another layer of gelatin.

The special Jos-Pe camera

More than merely a photographic process, Jos-Pe was a complete printing system that offered the photographer all the necessary materials for printing in color (Fig. 1). This included the special and advanced “Jos-Pe camera” which allowed the photographer to make the three color separation negatives in one shot, avoiding the undesirable effect of time-parallax misalignments and allowing the photographer to take pictures of moving objects or portraits.



Fig. 1 - Jos-Pe catalogue, 1930¹.

² Koshof, G., 1986. *Die Farbfotografie III. Lexikon der Verfahren, Geräte und Materialien*. München: Laterna Magica /Callwey.

³ Pénichon, S., 2013. *Twentieth-century color photographs*. Los Angeles: The Getty Conservation Institute.

The camera was constructed in a trapezoidal shape, with a lens in the front, built by Zeiss, and two mirrors manufactured by Steinheil Sohne located behind the lens.⁴ This group of mirrors split the incoming beam of light into three individual beams, which exposed the three negatives located in the back of the camera, through the corresponding color filters: red, green and violet-blue, made with dyed gelatin sheets sealed between glass. In this manner, three black-and-white negatives on glass were obtained.

The Jos-Pe camera was inspired by the camera patented by Frederic Eugene Ives⁵ in 1899 in which mirrors were used to split the beam of light inside the body of the camera and was probably one of the greatest contributions made by the Jos-Pe company to the color photography industry.

The three color Jos-Pe printing technology

In the Jos-Pe process, the three relief printing plates on glass used to obtain the final prints on paper were obtained from three black-and-white negatives made with the Jos-Pe camera. The glass negatives were coated with a bromide silver gelatin emulsion. Due to the division of light inside of the camera, the quantity of light of each negative varied: 25% of the light reached the blue and yellow plates and 50% exposed the red one⁶.

From the three negatives, the three printing plates, or matrices, were enlarged to one of the common available formats (10x15 cm, 13x18 cm, 18x24 cm, 24x30 cm, 30x40 cm) taking into account that the ensuing print would be made by contact. The matrices were manufactured on glass and coated with a gelatin silver bromide emulsion as well (Fig. 2).



Fig. 2 - Jos-Pe printing plates on glass. J.Merkelbach. RP-F26748-2/3/4. Rijksmuseum

⁴ *Jos-Pe Farbenfoto*. 1927. 1930. Hamburg.

⁵ Ives, F.E. 1899. US Patent No. 632,573

⁶ *Jos-Pe Farbenfoto*. 1930. Hamburg.

The positive matrices were processed with a proprietary Jos-Pe tanning developer, that probably included pyrocathecin with soda, caustic soda or ammonia.⁷ The developer hardened the gelatin proportionally to the exposure to light and built up the necessary relief for printing. The unexposed areas (the non-hardened gelatin) would be removed under warm water. This method had already been described by Leon Warnerke in 1881 and developed and applied by Gustav Koppmann in different patents, some of them under the name of the company Jos-Pe.

To proceed with the printing process, each matrix was soaked in its correspondent Jos-Pe dye bath. The dyes were sold in solid form but dissolved in water for this step. The dyes would be absorbed by the gelatin on the positive plate and remain in it until put in contact with a wet proprietary Jos-Pe paper. Here, the dyes transferred to the paper, in this manner forming the image there. It was suggested to start with the blue matrix and continue with either yellow or red. Due to the difficulty of this step, it is common to observe misregistrations in the borders of the prints or blurry edges in the image.

Characterization of the prints

Fortunately, the Rijksmuseum collection includes a complete set with the negatives, the printing plates and the final print of a photograph by Jacob Merkelbach. This circumstance significantly aided in understanding the process and gave us access to the original materials that could be analyzed for this research.

Under the microscope, the Jos-Pe prints have a smooth continuous tone without any visible pattern. The dyes are shown in a soft tone, although sometimes individual particles are visible, perhaps due to its incomplete dissolution in water.

Another characteristic is the retouching process carried out by the photographer in order to improve the final image. Under specular light (Fig. 3) these corrections become visible, especially the ones created by scratching the surface of the print to make it lighter. Retouching techniques also included could also be done adding media with a brush or with a pencil, to darken lighter areas or add details.



Fig. 3 - Retouching technique on a Jos-Pe print, observed with specular light.
J.Merkelbach. RP-F-F03967. Rijksmuseum

⁷ Willekens, L.C.C., 1926. *Het Jos-pé Kleurenprocédé*. Fotografische bibliotheek, 11A. Dordrecht: C. Morks Cz.

All of the prints in the Rijksmuseum collection have a matte surface, except one (RP-F-F03955) that shows a glossy coating on the surface. This coating did not fluoresce under UV irradiation, and no other analysis were carried out during this research project, so it could't be identified at this time.

Instrumental analysis

To better identify the paper and media we used X-Ray Fluorescence analysis. The top layer of the support paper contains barium and sulfur, which indicates that the paper was coated with a baryta layer, used to isolate the fibers of the paper and create a white, uniform base for the image.

Thanks to the donation of a sample of Jos-Pe paper from the photographic archive of Institut de Estudis Fotogràfics de Catalunya (IEFC, in Barcelona), we were able to perform a cross section (Fig. 4). In this analysis we confirmed that the baryta layer had an extra top-coat of a thin gelatin layer.

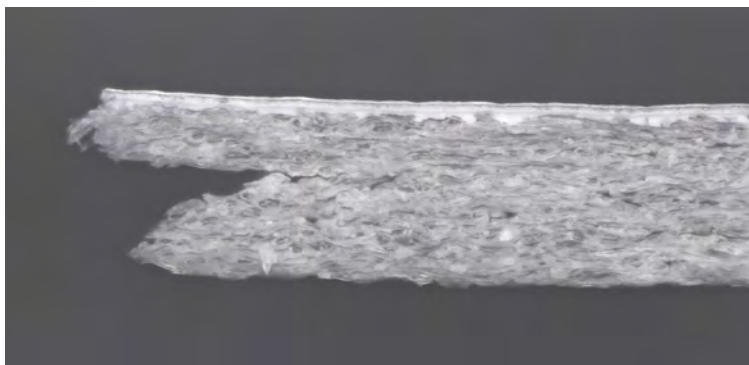


Fig. 4 - Cross section of a Jos-pe paper. Microscopy image (x700)

For the identification of the colorants we requested the expertise of Art Ness Proaño at the Rijksdienst voor het Cultureel Erfgoed (RCE). The dyes were sampled from the three printing plates, extracted from the gelatin and identified with liquid chromatography (UPLC). The red dye was identified as carmine (in ammonia), the blue dye was identified as Indulin B or Acid Blue 20 (sulphonated) and the yellow dye was identified as Dianil Yellow 2RI.⁸

With this knowledge we proceeded to reconstruct the process in order to artificially light-fade mockups on paper to analyze the chemical stability of the dyes. The red sample was exposed for two, four and eight hours, and changes already became apparent in the first exposure period of two hours, so a low lightfastness. The fading tests of the other two mockups have not been subjected to fading tests yet, however, the report from RCE suggests that, based on specialized literature, the lightfastness of the blue dye is BWS 4 and that of the yellow dye is 2-3.

Conclusion

This research brought light into this interesting process and its importance in the history of colour photography. The Jos-Pe process, far from a unique invention, benefitted from other inventions and patents. The basis of the printing system had already been described by Leon Warnerke, Leon

⁸ Proaño, A., Neevel, H., 2020, Analysis of Jos-Pe colourants used in Jacob Merkelbach's photographs from the 1930s. RCE Research Report No. 2018-126. Ministry of OCW, Cultural Heritage Agency of the Netherlands, Cultural Heritage Laboratory. Amsterdam

Didier and Gustav Koppmann. The Jos-Pe camera was inspired by the Ives camera from 1899. The three Jos-Pe dyes are common in the literature of dye imbibition processes and were also used in the Pinatype. The Jos-Pe paper was a typical paper with a baryta layer and topcoat of gelatin. However, the Jos-Pe process made the complex three-color photography available to a broader public, offering professional results to both amateurs and professional photographers. Our research indicates that the dyes are not very stable, although more research has to be performed in different circumstances.

Acknowledgement

I would like to thank my colleagues at the ateliergebouw in the Rijksmuseum: Idelette van Leeuwen, Rosina Herrera, Martin Jürgens, Dionysia Christoforou and Virginia Morant, and other contributors to the research: Art Ness (RCE, Amsterdam), Laia Foix (IEFC, Barcelona), Anneke van Veen (Stadsarchief, Amsterdam), Cristina Durán (Stadsarchief, Amsterdam), Caroline Vincart and Ann Deckers (FOMU, Antwerp), Sylvie Pénichon (Art Institute, Chicago), Vanessa Torres (Science Media Museum, Bradford). This research was made possible thanks to the Gieskes-Strijbis Fonds.

Bibliography

Jos-Pe Farbenfoto. (1927 and 1930). Hamburg.

Friedman, J. (2010). *History of color photography*. Milton Keynes, UK: Lightning Source.

Koshofer, G. (1986). *Die Farbfotografie III. Lexikon der Verfahren, Geräte und Materialien*. München: Laterna Magica /Callwey.

Pénichon, S. (2013). *Twentieth-century color photographs*. Los Angeles: The Getty Conservation Institute.

Proaño, A., Neevel, H. (2020). *Analysis of Jos-Pe colourants used in Jacob Merkelbach's photographs from the 1930s*. RCE Research Report No. 2018-126. Ministry of OCW, Cultural Heritage Agency of the Netherlands, Cultural Heritage Laboratory. Amsterdam

Wall, E., 1928. *Practical color photography*. Boston: American photographic Pub. Co.

Willekens, L.C.C. (1926). *Het Jos-pé Kleurenprocédé*. Fotografische bibliotheek, 11A. Dordrecht: C. Morks Cz.

Interpreting 35mm chromogenic slide film: the Ed van der Elsken case-study

Lénia Oliveira Fernandes¹

¹Nederlands Fotomuseum

Contact: Lénia Fernandes, loliveirafernandes@nederlandsfotomuseum.nl

Abstract

Now part of an extinguishing industry, chromogenic slide film appealed to many different types of consumers, both with amateur and professional photographer backgrounds. One of the Dutch artists who chose to explore the possibilities of this medium is Ed van der Elsken (1925-1990). From the 1950s onward, he captured colour images in a variety of films, later using them in slide-shows and in publications.

The Van der Elsken's photographic archive is kept at the Nederlands Fotomuseum (Rotterdam) and contains, among other objects, over 42.000 colour slides. This part of the collection was conserved, digitized and registered between 2016-2018, in an effort to mitigate the onset damage caused by mould. As a result of assessing and treating so many individual slides, the restoration project became an opportunity to explore the connections between the materiality and condition of different types of colour slide film and correlate them with Van der Elsken's artistic practice.

Through distinguishing in-camera originals and duplicates, identifying brand names and types of degradation, it is possible to visualize how even the stability of homonymous films varies, depending on when they were manufactured. Given the mass-produced nature of colour slides, the Van der Elsken's case-study is one step forward in standardizing the dating and interpretation of colour slides collections around the world.

Keywords: colour slides, chromogenic film, identification, dating, characterization, interpretation, case-study, 35mm film

Introduction

Chromogenic slide film, chromogenic positive film, chromogenic process transparencies, colour transparencies, colour slides and slide film are terms used to describe a type of photographic object that was mass produced by many companies from the mid 1930s all the way into the late 2000s. Even though they are an almost extinct part of the photographic industry, they became a commercial success especially in the 1950s-1960s, simplifying and normalizing the use of colour photography (Pénichon 2013, 160-161). The aforementioned terms describe photographs with a positive image made up of synthetic dyes in a gelatine emulsion that coat plastic film. Just as colour negatives, they are part of the dye coupler processes and their colour is obtained through the subtractive colour system, combining layers of yellow, magenta and cyan dyes. Also, cellulose acetate is the most common type of film support but it is also possible to find examples on a polyester base (Lavédrine 2009, 87). Chromogenic slides go through what is called reversal processing, therefore generating a direct positive photographic image instead of a negative (Pénichon 2013, 314). There are other colour transparencies on plastic support, including those based on the additive colour system (e.g., PolaChrome film), or created with the dye destruction process (e.g., Cibachrome transparencies) (Pénichon 2013, 49 and 217). These types of photographs will not be discussed in the following sections.

Chromogenic film manufacturers developed several products and tactics to entice consumer appeal. The possibility to project colour slides was marketed early on, and a practice that became part of family gatherings, school lessons and also artists' performances (Levie 2019, 20). They were also prominently used as a tool in the illustration of magazines and books (Wilhelm 1993, 644). Scientists in the photographic industry were therefore constantly searching for solutions that would simplify the production and use of colour slide film, as well as colour stability and accuracy (Pénichon 2013, 161; Shanebrook 2016, 404-413). It is therefore no surprise that specific products

evolved for decades, changing their inherent characteristics and ultimately affecting their permanence.

Ed van der Elsken's colour slide collection

Among the millions of photographs kept at the Nederlands Fotomuseum is the archive of Dutch artist Ed van der Elsken (1925-1990). Van der Elsken became known as a black-and-white photographer but was an avid fan of colour slide film and started to use it in the 1950s (Gierstberg 2018, 228). The over 42.000 colour slides in his collection contain images of life in the Netherlands and of Van der Elsken's travels abroad, showing his realistic and candid perspective of the world (Gierstberg 2018, 228-229). Almost all of these images were captured in 35mm format roll film and about 3% of them are duplicates. Van der Elsken organized his colour slide work in themes, most of the time geographically (whether they were locations he ended up visited often, (e.g., "Hong Hong") or only once, (e.g., "Greenland")). He also made some more general selections that contain photographs captured in different times and locations, making them sometimes more difficult to contextualize (e.g., "Kids around the world") (Elsken c. 1970-1990). Many of these images was included on Van der Elsken's photobooks and commissioned magazine work, as well as in slide show projections with an accompanying soundtrack (Gierstberg 2018, 237-240)

Because of onset biological decay, Van der Elsken's slides were at the core of a mass conservation, digitization and registration project that took place between 2016 and 2018 (Harrevelt and Pietsch, 2018, 246-250; Pietsch and Oliveira Fernandes, 2019a and 2019b). During the course of the project the opportunity arose to learn more about the history, production, identification and condition assessment of this type of photographs. This brought to light more insight into Van der Elsken's working methods but also a few guidelines that might be of use when working with similar objects.

Connecting historical context, materiality and artistic intention in colour slide film

There are many available sources on the topic of colour slides but the information they provide is often disconnected from one another. For example, the work of Wilhelm (1993) identifies many film types and describes some aspects of their degradation but does not provide any detailed illustrations. On the other hand, the database developed by Zbinden (2015) provides hundreds of images that help us identify and date film types. Yet, only short descriptions are provided, with few mentions of the objects' materiality and condition. The process of understanding the Van der Elsken slides became one of combining different perspectives: insights from historical, technical and conservation literature about the characteristics of the film types at hand and how they related to the artist's practice.

One of the challenges of this project was to determine whether the colour displayed by some objects displayed was a product of deterioration. There is no full proof method of knowing how colour film originally looked when it was first developed. Yet, with chromogenic materials it is safe to assume that some change has occurred, especially of the magenta and yellow dyes. This can occur both with light exposure and as a result of dark fading, especially in film produced before the 1980s (Pénichon 2013, 203 and 290). There is an implicit degree of subjectivity when accessing the fading of colour slide film, but knowing more about the materiality of the photographs in question is always helpful.

The interpretation of colour slide film can be divided into different areas that ultimately complement each other. See also Sommermeyer *et al.*, 2019, 164-167 for assessing slide artworks:

- Contextualizing information related to who and/or what is represented and how it was interpreted. This can be obtained, for example, in relation to textual information added to the slide's mount, or gathered through the artist's archives, publications, interviews, etc.

- Whenever present, the mount the photograph has been kept in should always be taken into consideration. It is often a source of textual information that originated when the film was processed (brand and film type, date), as well as later added annotations or symbols. The mount itself might be a standardized product that can be traced back to a specific period (e.g., Romano 2009).

- Identifying the literal components of the photographic image recorded on the film in terms of which locations and/or objects it represents. In an archive or museum environment, that information usually becomes part of descriptive keywords.

- Analysing the edge information along the film. In slides with mounts, this often expands the brand and film type information printed on the mount. Identifying film brands and types are also helpful in determine the period in which the photographs were made and to distinguish in-camera film originals from later copies. Imbedded numbering can be useful to determine the sequence in which a series of images were captured.

- Any inherent characteristics that can be connected to the way the object was made, such as the support's surface gloss, relief on the emulsion layer, applied coatings, image sharpness, overall hue, trimmed edges, other materials used as masks, etc.

- Other characteristics that are connected to physical, chemical and biological degradation of the object determined during the condition assessment, including discoloration (overall or localized, and which dyes might have selectively faded), issues with the acetate base (e.g., exuding plasticizers, acetate decay), mould growth, water damage, scratches, tears, adhesive residues, etc.

- To evaluate the overall discoloration of colour slides, one can start by observing their edges. Because that area of the film is not exposed during image capture, its colour is formed by the overlapping yellow, magenta and cyan dyes in the gelatine emulsion. When there has been no shift in the colour dyes, this area will look black; in cases where there has been colour fading, it will have a different hue (e.g., dark blue or purple). This does not apply to chromogenic positives copies obtained from a chromogenic negative, as their edges are typically colourless.

The following sections demonstrate a few examples of how these points were integrated in the analysis of Ed van der Elsken's colour slides.

Kodachrome & Ektachrome

As previously stated, most of the objects in the Ed van der Elsken collection were 35mm colour slides, and 90% of those were made in Kodak film. The frequency this brand appears in the collection is also testimony of this company's strong market hold in Europe and North America.

Many of the slides were still in the original mounts, the most helpful in terms of dating being Kodachrome slides in paper mounts, first introduced in 1939 (Pénichon 2013, 164; Romano 2009).

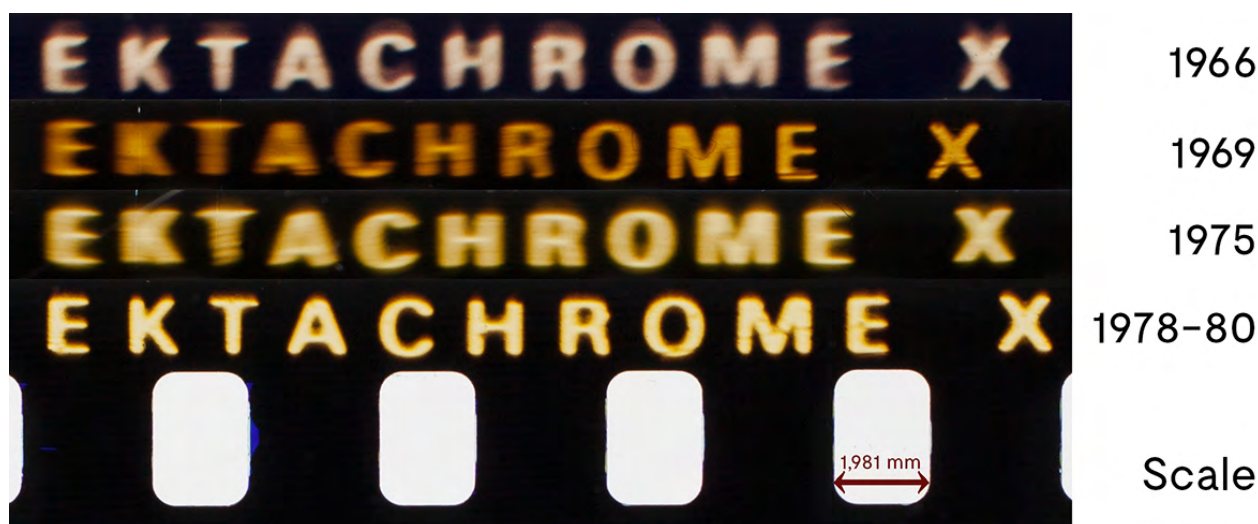


Fig. 1 – Evolution of the text along the edges of 35mm Kodak Ektachrome-X colour slide film according to dated examples found in the Ed van der Elsken collection at the Nederlands Fotomuseum.

Van der Elsken used at least seven different types of Kodachrome film in his career and was known to prefer this brand above others. Probably because of this film's slightly higher price, it can be found in commissioned work such as that done in the mid 1970s for Memisa's humanitarian aid campaign (Gierstberg 2018, 231 and 238). Those images were all captured in Kodachrome 64 film. However, the type of colour slide film that Ed van der Elsken most often used was Kodak Ektachrome. More than half of the entire colour slide collection is composed of at least fourteen different types of Ektachrome film. Photographs in Kodak Ektachrome X film (produced between 1963-1978) can be found in the collection in a period of over fifteen years (Pénichon 2013, 300). Although it hasn't been possible to conduct chemical analysis of these films, there are visual differences along the photographs' edges that can help distinguish them in time (Fig. 1). This type of variations in text font, colour, size, etc, is also displayed in other films, especially those that were manufactured for decades.

Fujicolor & Fujichrome

The second most common colour slide film brand found in the Ed van der Elsken collection is Fujifilm, in a total of 8%. He had a special connection to Japan and its culture and repeatedly visited this country, the first time during a world tour in 1959-1960 (Gierstberg 2019, 239-240). During that first visit he likely purchased two rolls of 35mm Fujicolor film to experiment with around the city of Osaka. Sixty-four of such colour slides remain. It is likely that this film was not easily available or even marketed in Europe at the time, even though it had been in production since 1948 (Fujifilm Europe 2010). Likewise, acquiring it and possibly having it developed in Japan was relatively inexpensive. These images look distinguished to other films because of the vibrancy of their dyes. The film's development (and relative longer stability) is akin to that of early Kodachrome film. In both these film types the colour coupler is added to the film during development, which makes them less likely to discolour later on but also makes their development expensive (Grossman 1955; Pénichon 2013, 182-183). Dark image areas have a characteristic milky white colour when viewed from the emulsion side [Fig. 2 - 3].



Fig. 2 - 3 –Ed van der Elsken, street scene, Osaka, Japan 1959-1960. 35mm Fuji Fujicolor colour slide film. Left: support side viewed with transmitted light, after treatment. Right: emulsion side viewed with specular light, before treatment. EVE-1113004-15 © Ed van der Elsken / Nederlands Fotomuseum

In the 1980s Van der Elsken travelled to promote the Japanese edition of some of his photobooks (Gierstberg 2019, 240). Around 1985-1986, he worked with a variety of Fujichrome films (100, 400 Professional and 400 Professional D) in the unfinished *Tokyo Symphony* project. A few images captured in Hong Kong, Paris and back at his home in Edam are also in this film. He must have been impressed by its quality of the film as there are over 3300 Fujichrome slides in the collection associated with a relative short period. It is not by chance that even now the images made in this film remain vivid and sharp. Wilhelm (1993, 3) tested the permanence of many films and Fujichrome film was (at that time) the 'longest-lasting transparency'. Even yellowed slightly overtime, it was still the recommended brand for permanence and projection.

On an early assessment of the slide on Fig. 4, this overall yellow-orange tone was taken for discoloration. However, upon researching this film, it became clear that this was unlikely, given the properties mentioned by Wilhelm (1993). It is important to note that the dyes in Fujichrome film such as the ones aforementioned are balanced for daylight use. In this case, Van der Elsken was photographing in an environment filled by artificial light, which technically required the use of a different film. That choice caused the entire image to shift towards yellow, therefore being an intrinsic characteristic of this image series. This is something Van der Elsken admittedly did countless times in his career (Gierstberg 2019, 231-232). Sometimes this happened in reverse light conditions, when he only had film balanced for a colder light temperature and wanted to photograph in daylight. In such cases, the image appears overall blue (Elsken 1978, n.p.; Pietsch and Oliveira Fernandes, 2019a, 79). For Van der Elsken, capturing life in colour when he had the chance to do so was more important than capturing technically accurate images.

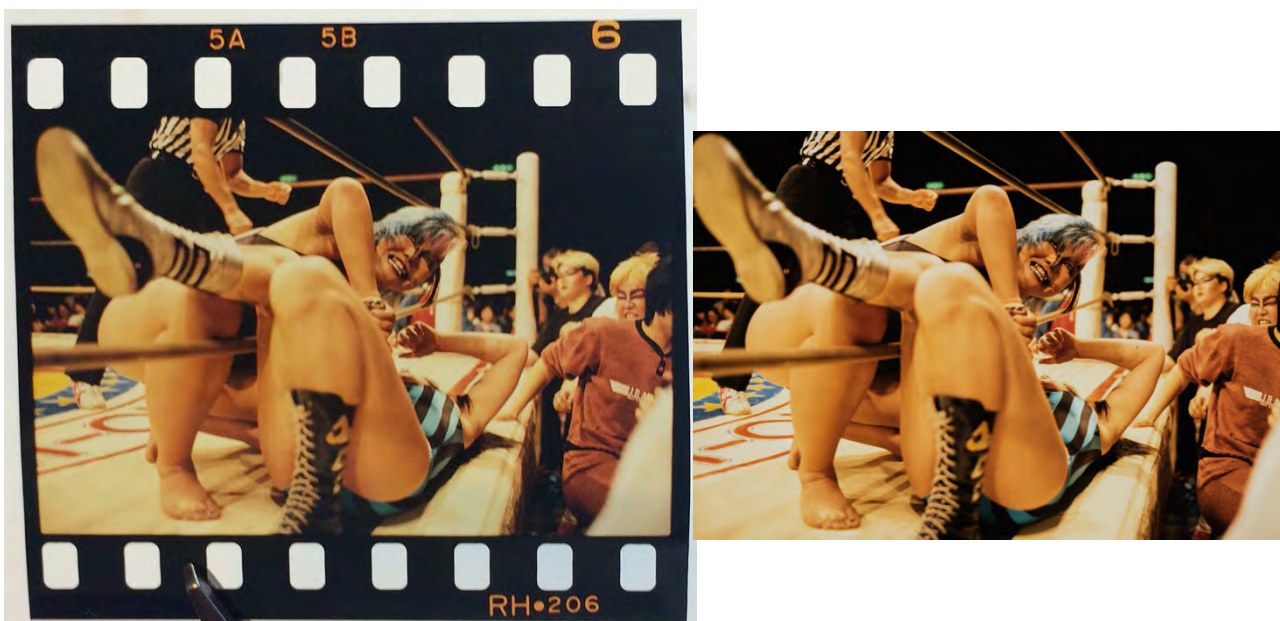


Fig. 4 - 5 –Ed van der Elsken, Keiko Aoki (a.k.a. Bull Nakano) and other female wrestlers during a match, Tokyo, Japan 1986. 35mm Fujichrome 400 Professional colour slide film. Support side viewed with transmitted light, before treatment (left) and after treatment and digitization (right). EVE-0207004-18 © Ed van der Elsken / Nederlands Fotomuseum

Unlike most of the collection, these objects displayed less signs of biological decay. Only 43% of all Fujichrome slides had to be submitted to wet cleaning. This contrasts with the rest of the collection, where mould was detected on almost 90% of all slides. It is quite likely that mould spores simply had less time to develop in these more recent photographs.

Ansochrome & Ansco Dupe

About 220 slides in the collection are in film manufactured by the General Aniline and Film Corporation (GAF). The earliest examples of Ansochrome film capture images in the Central African Republic in 1956-1957 and were featured alongside black-and-white photographs in the 1958 book *Bagara* (Elsken 1958). Van der Elsken used this film again during his visit to Mexico and the US in 1959-1960 and Super Ansochrome film for studio portraits in Amsterdam. These images present general discoloration because of dyes inherent instability, which according to Wilhelm (1993) were some of the worst in terms of permanence of colour slides. Because of mould growth, some of the Ansochrome slides in the Van der Elsken collection also display localized dye deterioration [Fig.6] (Nederlands Fotomuseum 2018). Many examples of early duplicates in the collection were also made in Ansochrome film. While unprojected examples have an overall blue-violet colour cast, those used during projection have clearly changed towards magenta [Fig. 7 - 8].



Fig. 6 - 8 –Ed van der Elsken, Woman with a fishbowl, Amsterdam, ca. 1960-1965. 35mm colour slide film. Support side viewed with transmitted light, after treatment. Left: Original slide in GAF Super Anscochrome Daylight type 525 film, (inverted digitally), with localized mould discoloration on the woman's shoulder. Centre and right: Duplicate in GAF Ansco Dupe Film. The example on the right faded except at the bottom edge where it was protected by the slide mount. EVE-0127002-11, EVE-0127001-11 and EVE-0127003-07 © Ed van der Elsken / Nederlands Fotomuseum

Agfacolor & Agfachrome

There are 16 images in the collection captured in Agfacolor L CT 18 film associated with different selections made for the *Sweet Life* and *Bagara* books, as well as within the 'South Africa' group (Elsken 1958 and 1966). This specific film was produced by Agfa between 1958-1962, and as previously stated, the colour images included in the *Bagara* book were captured between 1956-1957 (Zbinden 2015). It was therefore concluded that all slides made in this film likely came from a single roll that was used in South Africa in 1959-1960 (Fig. 9).

The colour in the Agfacolor slides is generally still very good, especially when compared to those in Agfachrome CT 18 film, a film manufactured between 1962-1974 (Zbinden 2015) (Fig. 10). Van der Elsken used this film around 1966-1968 but it has unfortunately faded towards magenta. These films are a good reminder that more recently manufactured films are not necessarily more stable than others previously produced by the same company.



Fig. 9 (left) –Ed van der Elsken, South Africa, ca. 1959-1960. 35mm Agfa Agfacolor L CT 18 colour slide film. Support side viewed with transmitted light. © Ed van der Elsken / Nederlands Fotomuseum

Fig. 10 (right) - Ed van der Elsken, Belgium, ca. 1968. Agfa Agfachrome L CT 18 colour slide film. Support side viewed with transmitted light. EVE-EVE-0820001-0 © Ed van der Elsken / Nederlands Fotomuseum

Scotch Color Slide 1000

About 160 slides of the Van der Elsken collection are on this film manufactured by 3M between 1986-1988. Identifying this film was helpful in dating it, as it had a limited production period. Ed van der Elsken created colourful images of the Parisian nightlife that because of that 1000 ASA sensitivity have a more noticeable grainy structure (Fig. 11 – 12).



Fig.11 - 12 –Ed van der Elsken, Nightclub, Paris, ca. 1986-1988. 35mm 3M Scotch Colour Slide 1000 colour slide film. Support side viewed with transmitted light. Left: Before treatment. Right: Detail, after treatment. EVE- 0204013-19 © Ed van der Elsken / Nederlands Fotomuseum

Conclusion

Regardless of their current geographical location, colour slide film collections around the world are likely to have similar characteristics and issues as those in the Nederlands Fotomuseum. The approach taken on the Ed van der Elsken project has since been applied in other slide film collections in the Nederlands Fotomuseum by artists such as Koen Wessing (1942-2011) and Chas Gerretsen (b. 1943). It has been helpful in their in the identification, conservation and interpretation and could be used as a baseline to understand similar collections worldwide.

Nonetheless, there are still many aspects of colour slide film that need further research as they have literal and figurative layers of complexity. Our collective approach to these materials needs to be interdisciplinary, integrating the study of the objects with their historical, cultural, and social contexts.

Acknowledgments

The author would like to thank: A. Hillhorst and all of the Ed van der Elsken restoration project sponsors; K. Pietsch (University of Amsterdam); the Nederlands Fotomuseum staff, especially A. Behrens, M. v. d. Broek, B. Donker, F. Gierstberg, L. v. Harreveld, E. Loode, M. van Oosterhoudt, H. Verdonk and M. v. d. Winkel; L. Pereira (doctorate student, Leiden University/KABK); I. Vasallos (The National Archives, UK); everyone along the years who has shown interest in this topic.

Bibliography

Baldwin, G. and Jürgens, M. (2009) *Looking at Photographs: A Guide to Technical Terms*. 2nd edn. Los Angeles, US: J. Paul Getty Museum.

Elsken, E. van der (1958) *Bagara: foto's uit equatoriaal Afrika*. Amsterdam: De Bezige Bij.

Elsken, E. van der (1966) *Sweet Life*. Amsterdam: De Bezige Bij.

Elsken, E. van der (c. 1970-1990). Register dia archief. Document with description of colour slide groupings, Ed van der Elsken collection, Nederlands Fotomuseum, Rotterdam, The Netherlands.

Elsken, E. van der (1978) *Hallo!*. 1st edn. Bussum: Van Holkema and Warendorf, n.p.

Fujifilm Europe (2010) 'Innovation History'. Available at: <https://www.fujifilm.eu/eu/about-us/history/innovation-history> (Accessed: 21 February 2021).

Gierstberg, F. *et al.* (2019) *Lust for Life: Ed van der Elsken in Colour*. Translated by J. Bemont and J. Tucker. Eindhoven: Lecturis.

Lavédrine, B. *et al.* (2009) *Photographs of the Past: Process and Preservation*. 2nd printing. Translated by J. McElhone. Los Angeles, US: The Getty Conservation Institute.

Levie, L. (2019) 'Conserving slide shows: photography conservation practice versus contemporary art conservation practice for slide transparencies', in Stigter, S., Jansen, E., and Snijders, E. (eds). *Contemporary Art Conservation Student Symposium 2019*, Amsterdam: University of Amsterdam, Faculty of Humanities, Conservation and Restoration of Cultural Heritage, pp. 19–25. doi: [10.21942/uva.9917207.v1](https://doi.org/10.21942/uva.9917207.v1).

Nederlands Fotomuseum (2018) *Archive Dive #5 Restauratie kleurendia's Ed van der Elsken* (2018). Available at: <https://www.youtube.com/watch?v=lp6zmbjVEoE> (Accessed: 5 March 2021).

Pénichon, S. (2013) *Twentieth-Century Color Photographs: Identification and Care*. Los Angeles, US: Getty Conservation Institute.

Pietsch, K. and Oliveira Fernandes, L. (2019) 'Mouldy Matters: Conserving Ed van der Elsken's 42.000 colour slides', *Topics in Photographic Preservation*, 18, pp. 167–180.

Romano, A. (2009) 'Kodachrome Slide Mount Chart', *trainutz.com*. Available at: <http://trainutz.com/rcMOUNT.shtml> (Accessed: 21 February 2021).

Shanebrook, R. L. (2016) *Making Kodak Film: The Illustrated Story of State-of-the Art Photographic Film Manufacturing*. Expanded 2nd edn. Rochester (NY), US: Robert L. Shanebrook.

Sommermeier, B. *et al.* (2019) *Back to the Future!: Riding the Slide Carousel = Back to the Future! Im Karussell der Diakonervierung*. Bilingual edition. Edited by B. Sommermeier and C. van Haaften. Hamburg: Kerber.

Wilhelm, H. (1993) *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures*. Grinnell (IA): Preservation Publishing Company. Available at: http://ethw.org/w/images/7/79/Wilhelm_and_Brower.pdf (Accessed: 14 April 2018).

Zbinden, E. (2015) *Historische Kleinbildfilm Datenbank*. Available at: <http://bilderdienst.ch/> (Accessed: 14 April 2018).

Truelight: from film to digital, 2000 - 2015

Richard Kirk

FilmLight Ltd

London, UK

Contact: richard@filmlight.ltd.uk

Abstract

In 2000 motion pictures were graded on computer monitors, sometimes with simple 1D LUTs to simulate the film tone curve. The film grader had to guess how their images would look on film. Truelight was a set of tools for soft proofing of film on a video or computer display, and hardware that applied the transform to video in real time. The evolution of the Truelight tools captured the state of the motion picture industry in those transformative years.

Keywords: Truelight, film, calibration, soft proofing, video, digital cinema.

Introduction

In 2000, I worked at the Computer Film Company (CFC) in Soho, London. CFC had their own film scanner and CRT-based film recorder, and they digitally edited film images to a high standard. Film colours were defined by negative density, with 10-bit RGB values mapped into CMY negative densities in steps of 0.002 density, giving a negative density range of just over 2.0 density units, similar to the Kodak Cineon standard (Patterson, 2001).

The ‘answer print’ was a lab print from the camera original. If there was no grading, and your film recorder could record the full density range, you could go from film to digital and back to film again and get the same colours. The digital intermediate film stocks had none of the colour cross-coupling components like the camera stocks had, because they were intended for narrow-band RGB exposures, so RGB mapped onto CMY densities with little cross-coupling. Unfortunately, CRT tube-based recorders had trouble getting the exposures that colour intermediate films needed, so they often used the low exposure end of the negative density range for speeds. This lost some print density range; this was not obvious where you were on the ‘shoulder’ of the print curve, but it did limit the saturation of some pastel colours. Advertisements were short, and wanted bright colours, so film adverts usually used the full density range, while features did not. If your tube-based recorder was still not putting out images fast enough, you could load it with camera stock: this was more sensitive but it had been developed to give pleasing images with full-spectrum scenes, and not for three narrow-band RGB exposures.

The 10-bit images could be viewed on a computer monitor. High RGB values recorded as high negative CMY densities, but printed as low CMY densities: the images were ‘the right way up’ but looked very ‘flat’ with low contrast. You could boost the contrast with an ‘S’-shaped 1D LUT. This gave realistic greys, but colours were then too saturated. Graders learned to ignore these saturated colours, and to imagine the film might look. If they could get their images out to film by 4 pm, they could usually expect to have the print ready for viewing in ‘dailies’ at 10 am the following day.

By comparison, going from film to video was relatively easy. You would put the film into a telecine machine, and it produced video. There had once been analogue methods for changing the frame rate, but most telecine machines of 2000 grabbed digital frames, so it was a small step to saving the scanned digital images. Telecines did not have the resolution or the stability of the pin-registered film scanners, but they were a fast, mature product.

A video suite would probably have a Sony BVM CRT with a standard D65 backlight and grey wall. The BVMs had extra lines at the top of the display that were monitored by internal electronics to keep the tube beam current stable. If you had one of these, it could remain stable for months. But they were expensive, so most of the cheaper grading seats used CRTs without this stabilization. These cheaper monitors might give consistent colour for days, and then one morning all the blacks would look grey. The monitors had lift, gamma, and gain knobs on the front, which the grader could tweak. They could put up a standard image (the ARRI test image was a favourite) and tweaked the controls until they got the familiar look. When I started, I tried to control this by having a photographic enlargement of this image stuck to a D65 light box that Verivide made for us.

What was the video tone curve? Rec.709 defined the tone curve of the camera, and it clearly was not that. The Rec.709 camera tone curve was designed to give a pleasing image on a typical CRT, when viewed in low light. That tone curve would typically have a gamma of about 2.5 when set up properly, and when adjusted using the PLUGE test, it would give a similar gamma in the shadows. But even the Sony BVM CRTs had visibly different tone curves. You hardly ever saw two in the same room, so many people never noticed this. We used a tone curve function that was fitted to the average of five examples of the same model of Sony BVM, and that lasted until Rec.1886 was adapted by the ITU.

If video was not consistent, how consistent was film? The print lab was selected by the client for the project, and may have been selected for the best quote when producing the final cinema prints. If you printed a Cineon reference 445 grey patch, most labs in London could get the print to within 0.1 of the expected 1.09, 1.06, 1.03 density. They gave you a piece of computer paper tape which gave the exposure settings, so they could do it again. But if they printed the same negative a week later, it might be visibly different.

Projection was variable. I measured projector open gate whites less than 5000K and over 7000K, on London, and with 500K variations between the centre and the corners. Adjusting a film projector lamp-house was an art, and like much art was always abandoned, never finished. The projection corners could be half as bright as the centre.

CFC bought an early Arrilaser film recorder. The writing was on the wall: the day was soon coming when post houses would buy or hire the equipment they needed, and did not need their own technical group. So, before we were pushed out, six employees and one contractor left CFC, and helped start FilmLight.

Colour conversion

Here is a diagram taken from an early Truelight document...

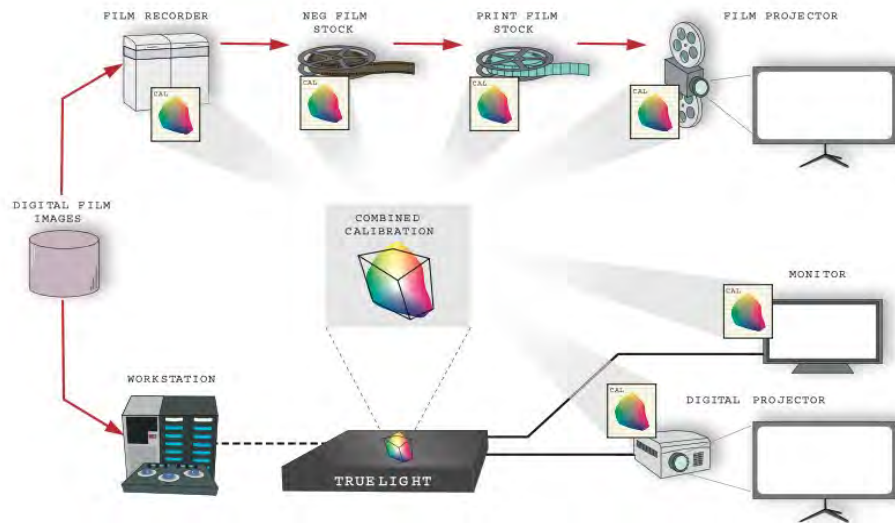


Fig. 1 – Truelight Calibration

We made a colour conversion box that could perform a general 3D colour conversion in real time on a monitor signal. This sat between the grading station and its display, so the grading workstation worked in the RGB they send to their film recorder, and our hardware applied the conversion to match the appearance on their display. The hardware did the processing using an FPGA chip with on-board RAM that was able to apply a 16x16x16 cube with 12-bit shaper LUTs (4 bits address and 8 bits fraction). The cube was interpolated using tetrahedral interpolation, which uses less weight for off-axis points than trilinear, and gave a smoother greys.

There was an early version of the Truelight hardware box that handled analogue video, but this was never sold. The commercial versions took used SDI for input and output. The cubes were loaded over a serial line, or over Ethernet, from a laptop or from a calibration workstation called the Cube Builder. As well as converting the video signals, the hardware was later programmed to display a cursor and report the incoming RGB values at that point, and it could display RGB patches for display calibration. The hardware could also convert between the different formats for RGB and YCrCb, with and without legal ranging.

Many graders preferred the feel when working in film density. The 'S'-shaped tone curve meant the film white and black points stayed close to white and black when you scaled or lifted the RGB values.

Film Calibration

The X-Rite TR-310 densitometer was widely used. We had a 20-year old one, and bought a new one. When calibrated using the same standard film, the differences were tiny. This was the obvious choice for measuring film. It could take a measurement and return the values over a serial port. We made a modified deck with a motorized drive, and a latch that could lock the head down. When the head was down, it fitted through a hole in a pressure plate that held the film in place by its edges.

We provided the calibration as a service to our customers. We would make a set of digital images with coloured patches. These typically had 1241 patches, for a 9x9x9 body-centered lattice of points in the film recorder space. A later improvement arranged the patches so each frame was filled with similar coloured patches, to reduce the effect of flare. The resolution of the images was matched to the customer recorder and working practice, as the exposure could vary with the resolution.

The exposure also included a grey patch with instructions for the lab to print to status A densities of 1.09, 1.06, 1.03. I am not sure all labs did that: I found a couple that would always print to 1.1 in each channel, but as long as they did what they did consistently, it should work. When the prints were not close enough, we could simulate the densities we measured. We had to do this with the 'butterfly' demonstrations, but it was occasionally needed to check dailies too.

The client recorded out the test patches on their recorder as they would record frames for their current job. They sent the output to the lab for processing, and printing on the film stocks they wished to use. The films were sent to us, and we measured them on the motorized densitometer. I would measure the negative in Status M, and the print in Status A. The list of the chart values and the corresponding Status M values would be the calibration of the combination of film recorder, intermediate film stock, and lab processing. The list of the Status M negative densities and the corresponding Status A print densities would be the calibration of the print film stock, and lab processing.

We could not get a good measurement of a film projector running film, but I could measure the open gate with my PR-650 spectrometer. I could then measure the transmission spectra for all the film patches and calculate the CIE Lab values of the projected film. Even that was hard to do as the spectrometer needed long integration times for the dark patches, but we did it at least once for Agfa, Kodak, and Fuji stock. This showed that each film supplier used the same dyes for all stocks, and the differences between the suppliers were small. Most of the time we used a simpler approach: we measured the transmission spectra for clear film, and for cyan, magenta, and yellow patches with a density of about 1.0. I calculate the Status A density and the CIE Lab values for all the CMY densities. This spectral model was smoother than measuring each patch, and just as accurate as far as we could tell. If there were any errors, they were much smaller than the typical variations in lab processing, or the variations between the edges of the film and the centre.

We rarely calibrated projectors. The default D65 Xenon arc spectrum was usually used. If this did not look right, we could get a match by shifting the white point in Lab space. There is one notable exception: ARRI made a desktop 35mm projector called the Locpro. This was originally designed for displaying angiograms and not colour film, but it did use a Xenon arc lamp. It seemed to be just the thing for the film reference next to your grading suite, but the lamp had an unusual spectrum, which made flesh tones on film look grey. We had a calibration for the Locpro, so we could get a matching look on the display.

Display Calibration

There was no instrument that would measure the colour of a CRT over its full range. A good CRT could manage over 2000:1 contrast, which is what you needed to give a realistic simulation of film. As CRTs got older, they developed ‘tube glow’ and the blacks became grey, but this was uniform over the whole image so you did not notice it unless it got really bad. The LCDs of the day were not suitable for grading: it took many years for the contrast ratio to creep up to 800:1, and the grey you saw was not flat and uniform. The LCD monitors also had significant colour shifts with viewing angle. This is still a problem, but they were a lot worse back then.

A post-house such as CFC in 2000 might have a hundred or more CRTs. Some of these would be in blacked-out grading suites, others would be in ordinary office environments. If we were to keep that many CRTs in calibration, a calibration should only take a few minutes.

A typical display might go to 50 nits. If we had a 2000:1 contrast ratio, we would have to measure colour accurately down to 0.025 nits. Our solution was to make a 4-channel colorimeter with custom dichroics to match the CIE 1978 vision primaries. We found someone who could make dichroics and had spare capacity after a shift in telecoms technology. With these on 1 cm square Hamamatsu silicon detectors we could measure XYZ down to 0.005 nits.

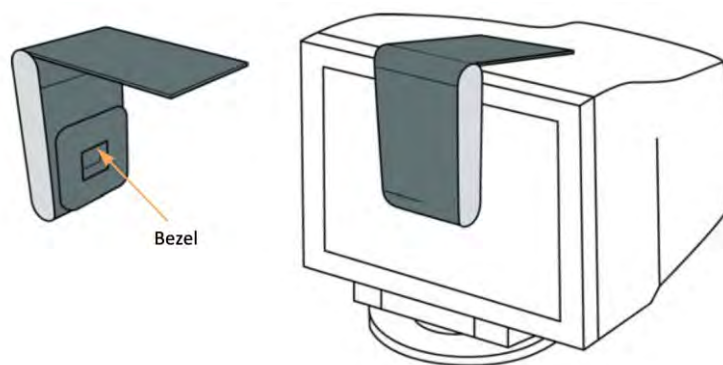


Fig. 2 – Truelight Monitor Probe

The probe hung from its lid when measuring a monitor. The lid was thin enough to fit above rack-mounted monitors. The foam bezel stopped most internal reflections within the monitor glass, so we could calibrate without blackout. There was a 45-degree mirror behind the bezel and the detectors were 10 cm further up inside the probe body, so the light they saw through the square aperture was only a few degrees either side of perpendicular. The probe pressed lightly against the monitor face, so it could be used with LCDs and plasma displays. A later innovation allowed it to be used with projectors too.

There was another option: we could calibrate displays by eye by matching stripes using a mid grey. This was only intended as an emergency measure when the probe was not available. It could not measure the display primaries or the brightness, but those were unlikely to change. This worked well, but was not popular.

Combining the calibrations

A full discussion of how Truelight works is beyond a short talk such as this one. I have attached a document (Kirk, 2006) which was issued with the Truelight library in 2006. This should give some idea how all the various elements were drawn together to match a display to projected film. There are physical parameters, such as the projector brightness, or the laboratory ‘printer lights’ setting; and psychophysical parameters that compensated for the brightness of the surround, the apparent darkness of blacks, and other things we cannot measure. These psychophysical parameters were significant, even when matching film and display in a well blacked-out room. We could get the same black on film and on a CRT according to the probe, but the film had clearly visible moving grain, while the CRT black was featureless; so the CRT looked ‘blacker’.

The only part we do not discuss in the reference is how we interpolate values through the lists. I thought this method was original, but it turned out to be very similar to Gaussian Process Regression or ‘Kriging’. You calculate an initial set of input and output values close to your target point using a weighted average. You calculate the covariance of the output value based on the input values using another set of weighted averages. You can then use the covariance matrix to correct for the difference between your initial input values and our target. If your points are well-spaced, this gives a smooth function that passes close to each point.

Truelight was shown at NAB in 2004. I had a screen with a Locpro projecting showing still 35mm film frames, and a small office digital projector showing digital images converted through Truelight side-by-side. The fit was not perfect, but it was close enough provided we used a fresh set of film prints each day to correct for fading. We could match the Locpro, or show what the same prints would look like in a cinema, or change the printer light settings.

People were impressed by the accuracy. I had to repeat the demonstration at customer sites to show it was not a trick, and I could do it with their projector, prints, and labs. This also means we can faithfully reproduce what a given image would have looked through the film process of the day.

Truelight after 2004

For the next ten years, a lot of the motion picture industry ran off our one densitometer. Truelight slowly improved. There was nothing dramatic, but we got to understand why some colours gave problems, and how to pick a better colour when we went out of gamut. We found a small Callier correction might help with colour films, though you got much less diffraction from soft-edged dye clouds.

We developed inverse transforms for Star Wars III. This was shot using digital cameras, as was Star Wars II, and dailies used a digital projector. The plan was to use the colours that were common to the film and digital gamuts. Truelight needed to produce gamut cubes that worked the other way: that looked right on the digital projector, but highlighted the colours that lay outside the film gamut, or clipped those colours to the film gamut. The modular nature of the Truelight software meant we could do this without dramatic changes.

Baselight replaced the Truelight hardware with its own internal processor. This was in turn replaced by transforming in the GPU when this became easy to do.

The Monitor Probe did work with new, high-gamut projectors like the Barco DP90P. It returned good XYZ values when the display primary peaks lay close to the vision primaries, but the DP90P red was half-way down the long-wavelength side of the red X peak. This meant small errors in dichroic production or alignment were amplified. We replaced this with the Truelight Projector Probe, which had the same XYZ colorimeter but also a spectrometer, so we could use the spectrometer to measure the primaries, and calibrate the colorimeter at the same time. The Projector Probe is no longer sold: displays are now brighter than they were, and they can saturate the colorimeter. There is no obvious way to support OLED displays with a fourth primary. This does not matter so much: projectors are calibrated using a spectrometer, and the new flat-panel displays are much more stable than CRTs were, so we can generally use them with their factory settings.

Simulation of old film processes

The Truelight tools can be used to simulate other film processes.

Technicolor process 1 used a 2-colour camera and projector and a film (Kodak Super-X) that is unavailable today. I do not know what glass filters they used, but the red and cyan glasses are probably the same today. The film probably had a spectral sensitivity that was similar to the later panchromatic stocks for which I had data, and the camera spectral sensitivity was dominated by the filters anyway. The tone curve would have been shorter, so I modified that by hand. I picked two modern glasses from Instrument Glasses, red 8210 and light blue 4264, and measured their transmission spectrum. Technicolor may have used a different thickness in the camera or the projector, but this seemed to work. I assumed the camera was filtered so a neutral fell on the same position of the film tone curve. The film tone curve would have been shorter than the Kodak Tri-X stock for which I had data, so I corrected the negative densities to model my guess for that. I then balanced the light through the projector to give a balanced white.

Technicolor process 5 used a Kodak Eastmancolor 3-colour negative film in the camera, printed three panchromatic matrix prints through filters, and then used these to generate cyan, magenta, and yellow dye levels by dye transfer. I did not have the original 3-colour stock, but I substituted measurements from Kodak 5218 and that seemed to work. I simulated exposures through Wratten filters 25, 58, and 47b, and a probable panchromatic tone curve to make the matrix. I then simulated the exposures in the final film, and translated that to dye levels. I did not know the dyes used by Technicolor, but Roscolux lighting filters are sheets of gelatin on a matrix imbibed with light-fast dyes, so I based my simulation on Roscolux filters 4390, 346 and 12. The transform as shown on the ARRI test image may not look convincing, but this is because the original scene was not lit as for a Technicolor set: a Technicolor set used 'flat' lighting with no deep shadows anticipating the heavy dyes of the final print. The reds and yellows are way outside the gamut of most displays too. But the right image, displayed on the right projector, can give a very good feeling of Technicolor.

In the talk I show simulations of other film processes. These are not presented as models of historical reconstruction; they just show that a simple model based on guesses can give a feel for the medium as it might have been.

Bibliography

Kirk, R. (2006) 'Truelight Software Library 2.0',
FL-TL-TN-0057-SoftwareLib

Patterson, R (2001) 'Understanding Cineon',
<http://www.digital-intermediate.co.uk/film/pdf/Cineon.pdf>

The effects of finish coatings on ultraviolet and visible light stability of inkjet prints

Ella Solomon¹

¹Post-graduate student of the programme ‘Conservation and Restoration of Cultural Heritage (photography)’ at the University of Amsterdam

Contact: solomonconservation@gmail.com

Abstract

As part of the technological developments in inkjet printing industry, products such as finish coatings are marketed to achieve long-lasting durability of the prints. This study shows how the colours of coated inkjet prints change over time as a function of exposure to UV and visible light radiation. Six finish coatings for inkjet prints were chosen for their various protective properties. The finish coatings were applied on eighteen samples: twelve directly on Hahnemühle unprinted Photo Rag® fine art paper and six on printed paper with Epson UltraChrome Pro inks. Three of the coatings were analysed using GC-MS. The analysed samples were exposed to a spectrum of 320–800 nm using Xenontest for approximately 121 megalux hours overall. To quantify the change in colour, the difference between unexposed and exposed areas was compared in each sample using the ΔE^* value. The results indicate change of colour as a reaction of different chemical compositions.

Keywords: Inkjet; coating; UV and light stability; Xenon; GC -MS; colour measurements; Hahnemühle Fine Art paper; Epson UltraChrome Pro inks.

Introduction

Inkjet printing is a common practice in digital photography and is employed by contemporary artists and in day-to-day life in the office or at home. An inkjet print is an image created by ink droplets which are deposited on a substrate (e.g., paper) by a printing device based on commands sent to it from a computer. Inks for inkjet prints are composed of a colourant (dye or pigment), liquid vehicle (water or other solvent that evaporates after drying, oils, waxes or UV-curable polymers) and other additives that are incorporated to improve lightfastness and protect against abrasion (Jürgens, 2009). As part of the technological developments of inkjet printing, products such as finish coatings were marketed to achieve long-lasting durability of prints.

Due to their transparency, finish coatings applied on inkjets are hard to identify and can present unfamiliar deterioration mechanisms on prints. Since no research was done before on finish coatings for inkjet prints, gaining more knowledge on their nature can be beneficial when deciding on conservation treatment procedures and exhibition guidelines. This study will discuss the photostability qualities of six inkjet finish coatings and their effect on Epson UltraChrome Pro inks and Hahnemühle Photo Rag® fine art paper. The chosen products are typically employed by printing studios and photographers worldwide for their aesthetic and durable characteristics. The six finish coatings are as follows: Hahnemühle Protective Spray (coating #01) for inkjet prints on paper and the Hahnemühle Varnish (coating #04) for inkjet prints on canvas, which is liquid; Rauch Schutzlack Firnis für Fine Art Papiere for paper (coating #02),¹ applied by spraying and Rauch ClearShield™ Type C matte Seidenglänzender UV-Schutzlack” (coating #05) which is a liquid coating suitable for inkjet prints on canvas²; Breathing Color manufactures Glamour II (coating #03) for both prints on canvas and paper and Timeless Varnish (coating #06) for inkjet prints on paper or canvas, both of

¹ At the time of writing, Rauch does not manufacture inkjet finish coatings but only sells them using their own brand name. It is therefore important to clarify that the manufacturer of the spray coating Rauch Schutzlack Firnis für Fine Art Papiere for paper (coating #02) is unknown (Solomon, 2020).

² Manufactured by Marabu (a US company).

which are liquid finish coatings.³ According to the products' labels, each finish coating has different polymeric binders, different additives and different UV absorbers (UVAs) and/or Hindered Amine Light Stabilisers (HALS). Although the finish coatings have been created to improve the prints' life expectancy, little is known of their material content and thus for their long-term performance.

Three of the coatings were analysed using GC-MS. The material analysis provided further understanding of the polymer matrices and the UV and light resistance additives. The analysed samples were exposed to a spectrum of 320–800 nm using Xenontest for approximately 121 megalux hours overall. To quantify the change in colour, the difference between unexposed and exposed areas was compared in each sample using the ΔE^* value, calculated from chromatic coordinates $L^*a^*b^*$. The results were then interpreted with a preliminary literature research that was done on photostabilisation and degradation mechanism of polymer binders in coatings.

Sample creation

Four sets of samples were created by Ryan Boatright at the Atelier Boba printing studio in Paris. The chosen substrate was Hahnemühle Photo Rag® 308 gsm, cut to sizes of 13 cm by 4.5 cm. Some of the samples were printed using Epson Ultrachrome Pro inks. The six chosen coatings were applied systematically to avoid different thicknesses as much as possible.

- *Set A: Unprinted coated samples for step ageing:* each specimen was fully coated with the following finish coating for inkjet prints: #1 Protective Spray by Hahnemühle (for inkjets on paper). #2 Schutzlack Firnis für Fine Art Papiere by Rauch (for inkjets on paper). #3. Glamour II matte by Breathing Color (for inkjets on paper). #4 Protective Varnish by Hahnemühle (for inkjets on canvas). #5 ClearShield™ Type C matte by Rauch (for inkjets on canvas). #6 Timeless by Breathing Color (for inkjets on canvas). #7 Control: unprinted and uncoated piece. (Fig. 1).
- *Set B: Unprinted coated samples as control group* (not intended to be aged).
- *Set C: Printed samples fully coated for ageing:* each specimen was coated fully with the six finish coatings, with the addition of a control (printed and uncoated inkjet). (Fig. 2).
- *Set D: Half-coated printed samples for ageing:* each specimen was half coated with the six finish coatings/ (Fig. 3).

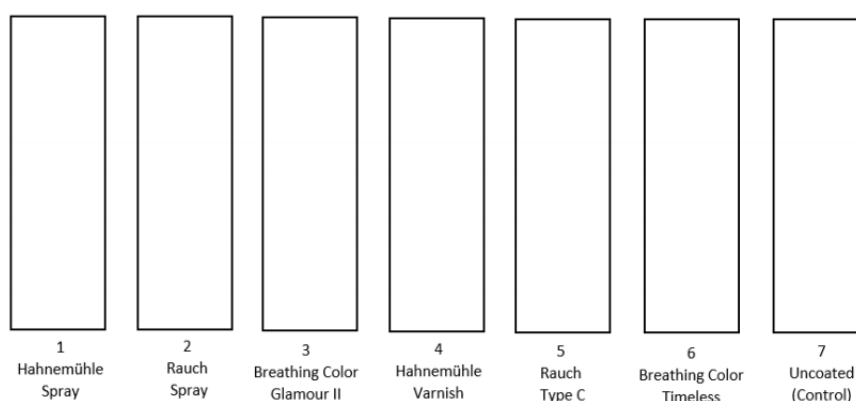


Fig.1. Illustration of sets A and B. Set A was employed for step ageing, and Set B was employed for comparison with Set A. Image: author.

³ Finish coatings was chosen for both inkjets on paper and on canvas, but testing was done by employing only on paper substrate as it was found that coatings designated for canvas are also used on papers and vice versa. The limitations of time and sources did not allow to test the photostability on canvas substrate.

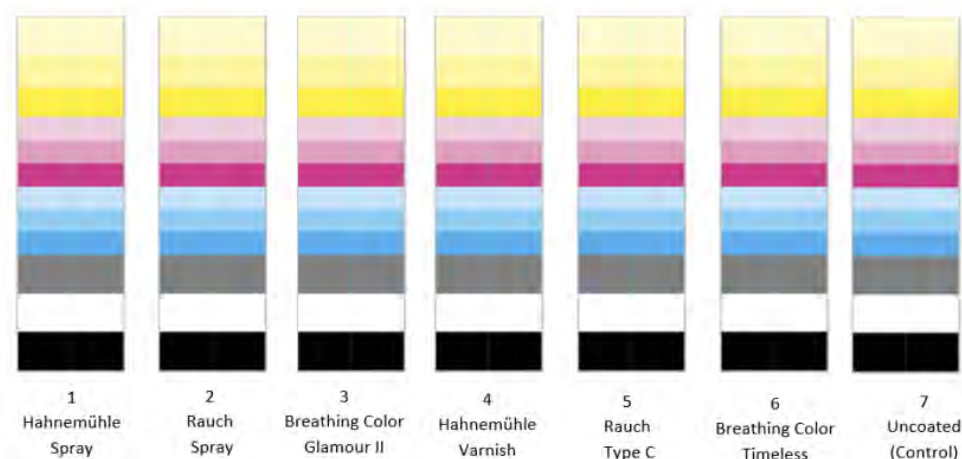


Fig.2. Illustration of Set C. Image: author.

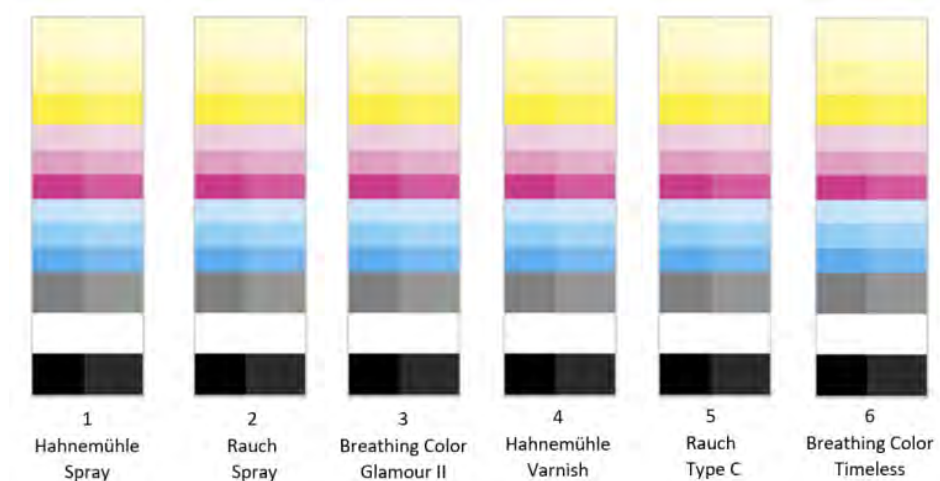


Fig.3. Illustration of Set D. Image: author.

Experimental

THM-GCMS

Ing. Saskia Smulders, MA, PD res. and Henk van Keulen from the Rijksdienst voor het Cultureel Erfgoed (RCE) performed the THM-GCMS. The formation of a suspension sample material was triturated with a few drops of a solution of tetra-methyl ammonium hydroxide in methanol (5%). The suspension was transferred to a metal pyrolysis cup and analyzed. Pyrolysis, hydrolysis and/or methylation took place in the fatty acids, the resin acids and the polymeric fraction of the sample. The total components mixture was separated with the aid of gas chromatography and the separated components were detected and identified by mass spectrometry. A Frontier Lab 3030D pyrolyser was used in combination with a Thermo Scientific Trace 1310 gas chromatograph and a Thermo Scientific ISQ mass spectrometer (Smulders and van Keulen, 2020).

Artificial UV and light ageing using Xenontest

In this study, the artificial UV and visible light weathering test was conducted by exposing samples in an Atlas Xenontest 440 weathering instrument under the supervision of Drs Agnes Brokerhof, a senior scientist at RCE. The samples were exposed to a radiation range of 320–800 nm, with a test chamber temperature of 40 °C and a relative humidity of 40%. The irradiance intensity of the xenon lamp was 50 W/m² using a window glass filter. The UV content is 0.4 mW/lumen and can be expressed as kJ/m², i.e., the total amount of UV energy on a surface. Photography test standards specify the use of lux (the total amount of visible light energy on a surface) combined with hours as a means for quantifying dosage. Given that significant photodegradation resulting from exposure to the short-wave UV region can go undetected when only lux hours are employed, both spectrum components will be mentioned in table 1 (Ligterink, 2020).

The unprinted samples (Set A) were exposed and covered in five steps representing the increasing dose of UV and visible light: on the first step the samples were exposed to 80,716 lux hours (lxh) and 122 kJ/m². Part of each sample was then covered and the exposure continued. The fully coated printed samples (Set C) were half covered before ageing and withdrawn after the final fifth step of ~121 mega lux hours (mlx h) and 181,414 kJ/m². The half-coated printed samples (Set D) were not covered and were withdrawn after the final step.

Step 5	~121 mlx h 181,414 kJ/m ²	Representing 100 lux for 137 years
Step 4	~57.5 mlx h 86,860 kJ/m ²	Representing 100 lux for ~65.5 years
Step 3	~17.6 mlx h 26,612 kJ/m ²	Representing 100 lux for ~20 years
Step 2	3,114,710 lxh 4705 kJ/m ²	Representing 100 lux for ~3.5 years
Step 1	80,716 lxh 122 kJ/m ²	Representing 100 lux for ~1 month

Table 1. UV and visible light exposure doses for Set A.

Colour measurements

For the colour measurements, this study used the CIELAB colour space model, which employs three chromatic coordinates (L*, a* and b*). The measurements were performed using a Konica Minolta CM-2600d spectrophotometer with standard illuminant D65 and 10° circular illumination, with specular component excluded to eliminate gloss. The measuring area was 0.3 cm², and each measurement was performed at a different position in each sample to avoid defects and ensure comparable results as much as possible. L*a*b* values were taken from overall 94 areas. The colour variations before and after weathering are expressed as the overall colour difference (ΔE^*).

Gradual colour changes were measured in each sample of Set A using ΔE^* values for each step. Overall colour differences were also employed for set C. Measurements were taken in the saturated yellow, magenta, cyan and black of the coated samples of coated covered areas (represent ‘before ageing’) and coated exposed areas (represent ‘after ageing’ of approximately 121 mlx h) and compared with the uncoated printed and exposed area of the control to determine the colour change in the aged coated printed samples and to estimate the protective performance of the aged coating compared with an uncoated print. Colour changes noticeable by the naked eye were determined when ΔE^* is ≥ 1.5 .

Results

THM-GCMS

Due to time limitations, only coatings #02, #03 and #05 were analysed. There is no further information on the material content for coatings #01, #4 and #06 other than that mentioned on the products' labels. It was also not possible to fully identify the three analysed coatings and further analysis needs to be conducted to get better defined results. The material content that was found on THM- GCMS and mentioned by the manufacturers is addressed here only by the binder and the light stabilizing additives that are incorporated in the binders, as these component's light stability and the way they affect each other was studied the most in the published coatings literature. The findings are as follows:

- Hahnmuhle protective spray #1: the coating was not analysed. However, the products' label state the presence of light stabilizer called benzotriazole (BZT) that belongs to the UV absorbers family.
- Rauch Schutzlack Firnis für Fine Art Papiere #2: the coating was analysed and together with the product's label it was found to contain PEG-PVA as a binder and hydroxyl-phenyl triazine (HTP) as light stabilizer. HTP is also belong to the UV absorbers family.
- Breathing Color Glamour II #3: the coating was analysed and together with the product's label a combination of methyl acrylates and methyl methacrylates was found as a binder. No light stabilizer was found.
- Hahnemühle Varnish #4: the coating was not analysed and the product's label does not provide any information.
- Rauch ClearShield™ Typ C matte Seidenglänzender UV-Schutzlack #5: the coating was analysed and together with the product's label a polyester- urethane and styreneated acrylates binder was found. Benzotriazole and Tinuvin 292 which is a different type of light stabilizer called Hindered Amine Light Stabilizer (HALS) was found as well.
- Breathing Color Timeless Varnish #6: the coating was not analysed while the product's label state that acrylic copolymer acts as a binder. No light stabilizer is mentioned.

Color measurements

The main results from the experiment involving coating-paper systems (sets A and B) are as follows: The unprinted uncoated paper changed colour after approximately 17.6 mega lux hours and 26,616 kJ/m² UV content. Most of the coating-paper samples yellowed over time, except for Sample #05 (Type C matte by Rauch, liquid coating for canvas) in which the colour change is entirely unnoticeable at the maximum weathering step of approximately 121 mega lux hours and 181,414 kJ/m² UV content. (Fig. 4).

Colour changes in coating-ink-paper system show different behavior. The changes were mostly evident as the colour became lighter. At the maximum dose, the magenta and cyan inks on uncoated printed paper changed colour more than when covered by any of the coatings, indicating that the coatings in the coating-ink-paper system slow down colour changes of the prints. The results of the colour measurements show that most of the coated yellow ink (at the maximum exposure of any coating-ink-paper sample) had faded significantly. In contrast, the colour change in the coated magenta and cyan was slowed down by the presence of the coatings. Most of the coating-ink-paper system samples experienced significant colour change, except for Sample #05 (Fig. 5).

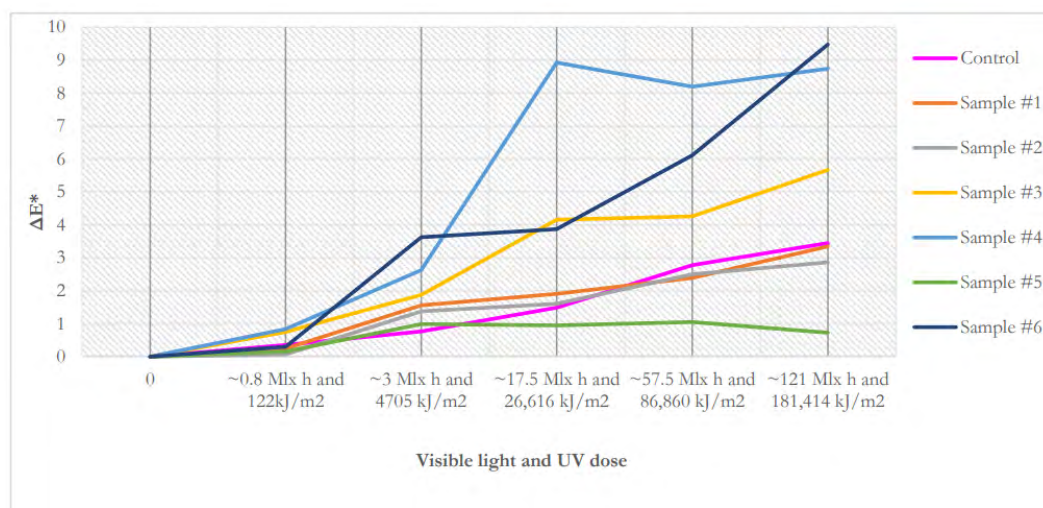


Fig.4. Comparison of colour change rates of six coated papers and one uncoated aged paper (control). The image above shows the trend of colour build-up (towards yellow) over time. Image: author.

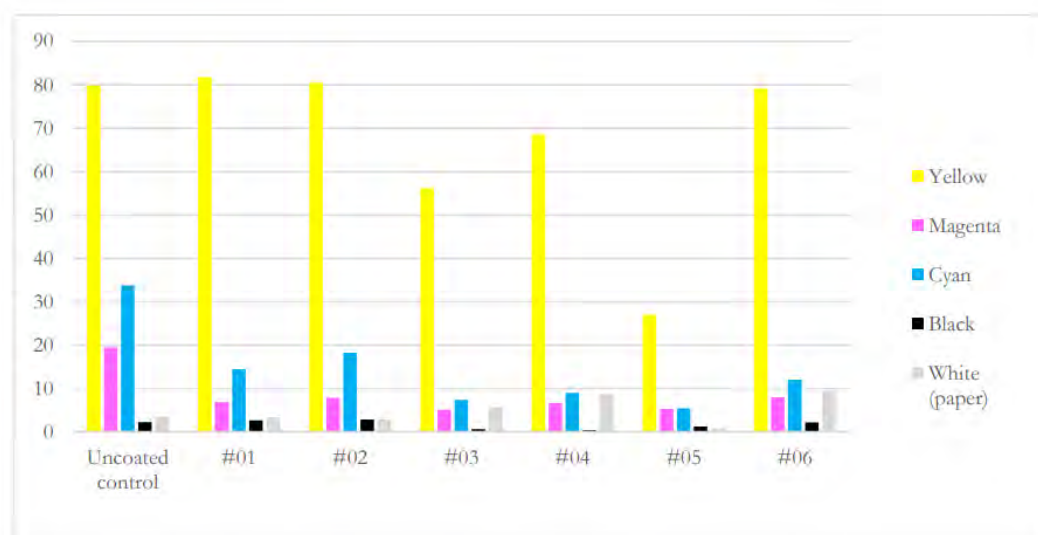


Fig.5. Comparison of the colour changes for the six coated printed papers before and after the maximum dose of ~121 Mlx h and 181,414 kJ/m². The chart provides a comparison of colour changes in each saturated ink (yellow, magenta, cyan, black or white-plain paper) and each ink's behaviour for the six coatings. Image: author.

Discussion

Preliminary theoretical study that was based on the polymer binders and light stabilisers that were found in the material analysis can offer some explanation to the results of the colour measurements. The material analysis using GS-MS found polymer binders and other materials, discovering PEG-PVA binder and BZT in Coating #02; methyl acrylate and methyl methacrylates as binder in coating #03, but no light stabilisers; and polyester-urethane and acrylates (MMA-BA) as binder, BZT and Tinuvin 292 in coating #05.

Studies have shown that chromophores⁴ are the main cause of colour changes that are reflected as yellowing. Light stabilisers protect coatings against light-induced damage by absorbing or scavenging harmful radiation, thereby preventing bond breakage that can result in the creation of chromophores. Effective UVAs should have absorption coefficients in the wavelength range for which the entire coating system is most susceptible to photodegradation. Photostabilising additives are divided into two groups: UVAs and HALS. The protection mechanism of a UVA basically consists of transferring the absorbed radiation into less harmful thermal (or vibrational) energy through an excited-state intramolecular proton transfer. The proton then returns to its original position, thereby enabling the molecule to release thermal energy (Jospíšil and Nešpurek, 2000). HALS protect polymer coatings against photooxidative damage, mainly through the formation of nitroxide radicals, which subsequently consume damaging radicals in a process known as the Denisov Cycle. The Denisov Cycle involves reactions that scavenge both polymeric and peroxy radicals by nitroxides and their conversion to nonradical products, with subsequent regeneration of the nitroxide (Hodgson and Coote, 2010). Due to the different protective mechanisms, the combination of UVAs and HALS in a polymer offers a major advantage in preventing colour changes (Jospíšil and Nešpurek, 2000).

The information accumulated from the theoretical study is difficult to interpret in terms of the reasons for the colour changes in the samples, given the numerous variables that might influence these changes. First and foremost, the colour change was measured as a combination of a coating and paper and a combination of a coating, ink and paper. It is difficult to evaluate colour changes when there are unknown materials in the ink, when the paper can react with the coating and when the materials within a coating can react with each other. Deducing the reasons that one coating-paper system has a greater tendency to yellow over another is therefore not possible within the confines of this study. The current research can only show how the colour changes in certain weathering conditions while helping evaluate the appearance of the samples. Nevertheless, the results yield some important information regarding chemical compositions. As mentioned before, the combination of UVAs and HALS provide coatings with better light fastness. Indeed, the printed and unprinted samples with coating #05, which had this combination, show less colour change. When no UVAs and HALS were found in the coatings, the colour change was much more significant.

It is important to bear in mind that the weathering conditions were extreme and demonstrated a scenario of coated prints exposed to solar radiation behind glass at 40 °C for a maximum dose of light that equivalent to 100 lux for 137 years. These conditions were employed to raise awareness of the possible presence of a coating that might otherwise go unnoticed. Photodegradation usually occurs within the UV-A range, with not much occurring within the visible light range. Thus, in stable environmental conditions where exposure to UV radiation is minimised, the coatings provide protection, and a significant amount of time would be required for photodegradation leading to colour changes to occur as compared with uncoated prints.

Conclusions

The results showed that uncoated paper yellows over time but that unprinted coating-paper systems yellow even more, except for one sample. According to the material analysis conducted, this coating contains a combination of light stabilizing additives. The colour measurements in the coating-ink-paper system showed that most of the coated yellow ink had faded, while the colour change in a coated magenta and cyan was slowed down by the presence of the coatings. Theoretical study can offer an explanation: most of the polymer binders in the coatings degrade within the UV-A range and

⁴ A chromophore is a region in a molecule where UV and visible light is absorbed, thereby exciting an electron from its ground state to an excited state, followed by a covalent bond cleavage. Chromophores can already exist in a molecule or can be created after a bond cleavage.

different light stabilisers react within UV-A spectrum. Thus, the rate of photodegradation slows considerably. Due to the different protective chemical mechanisms of light stabilisers, the combination of UVAs and HALS in a polymer offers a major advantage in preventing colour changes. Given the numerous variables and unknown materials that might influence colour changes, it is difficult to evaluate the reason for their occurrence.

Acknowledgments

The study was conducted as part of a master's thesis of the programme 'Conservation and Restoration of Cultural Heritage (photography)' at the University of Amsterdam and in collaboration with Rijksdienst voor het Cultureel Erfgoed (RCE). I am thankful to Katrin Pietsch, supervisor for the master's thesis and Dr René Peschar at University of Amsterdam (UvA). This research was made possible by Ryan Boatright, the co-founder of studio Atelier Boba. The experimental part was possible with the generosity of Drs Agnes Brokerhof, ing. Saskia Smulders, MA, PD res. and Henk van Keulen (RCE). I am also thankful to Drs Frank Ligterink and Dr Han Neevel at the (RCE), Prof. Dr Maarten van Bommel and Clara von Waldthausen (UvA) for their guidance.

Bibliography

Hodgson, J. L. and Coote, M. L. (2010) "Clarifying the Mechanism of the Denisov Cycle: How do Hindered Amine Light Stabilizers Protect Polymer Coatings from Photo-oxidative Degradation?". *Macromolecules*. 43 (10), pp. 4573- 4583. doi: 10.1021/ma100453d.

Jürgens. M.C. (2009) *The Digital Print*. UK: Thames and Hudson.

Solomon, E. (2020) *Purchasing Schutzlack Firnis für Fine Art Papiere in Paris*. (Email).

Jospíšil, J. and Nešpurek, S. (2000) "Photostabilization of Coatings. Mechanism and performance". *Progress in Polymer science*. 25 (9), pp. 1261- 1335. doi: 10.1016/S0079-6700(00)00029-0.

For the master's thesis and the complete bibliography please see: Solomon, E. (2020) *The effects of finish coatings on ultraviolet and visible light stability of inkjet prints*. Amsterdam: The University of Amsterdam. scripties.uba.uva.nl/search?id=c2962967.

Photographic and Cinematographic Film Repository (FiRE): identification of films for digital restoration

Arianna Crespi^{1*}, Giulia Morabito^{1*}, Alice Plutino¹, Alessandro Rizzi¹

¹ Department of Computer Science “Giovanni degli Antoni”, Università degli Studi di Milano

Contacts: Arianna Crespi, arianna.crespi3@studenti.unimi.it

Giulia Morabito, giulia.morabito@studenti.unimi.it

Abstract

Among the great variety of our Cultural Heritage, photographic and cinematographic materials are fundamental and direct witnesses of the past. The classification and restoration of these materials are often needed as they can undergo severe deterioration, aging and fading.

In the work of film and photo restoration, conservation and preservation, it is fundamental to analyse and study the original materials, in order to perform a retrieval or a correction faithful to them. In this context, the lack of technical information (especially for the oldest materials) and the absence of open source archives of the production companies, underlines the actual and concrete need of a database of physical, chemical and sensitometric data of films and photos. The aim of this work is the creation of a big database of cinematographic and photographic technical materials, in order to support the work of conservators, restorer and researchers, as the availability of information is essential for the preservation of our Cultural Heritage.

Keywords: film restoration, film database, sensitometry.

Introduction

Film restoration is a complex process involving many different fields, from the physical and chemical aspects to the cultural background in which the film has been produced.

For instance, the first step of film restoration is historical and philological research, as usually many different copies of the same photo or motion picture are available: some of them may have suffered censorship, some others may present intertitles, etc.

On the other hand, over the years, the film industry has faced a lot of innovations in many fields, such as the development of different film base materials, the introduction of different colouring techniques and the advance of many acquisition and projection instruments as well as printing and developing machines. The latest step of this evolution is the introduction of digital technologies, which today is going through a deep development in the acquisition and fruition techniques. In this context, it is fundamental to analyse, study and understand the chemical and physical composition of the different films to set up restoration workflows which are faithful to the original materials also employing modern acquisition and fruition instruments.

For these reasons researchers and restorers often rely on public archives to collect all the information needed for their work, as the documentation process is fundamental to perform a correct film restoration. However, the lack of strict international guidelines make this a hard task for the professional figures working on it as *film restoration still struggles to establish a binding professional code, comparable to those already in place in fine art restoration and heritage conservation* (Busche, 2006). The main goal of this work is the creation of an open source technical database of cinematographic and photographic materials, in order to support the work of conservators, restorer

and researchers. So far, the database includes technical data coming from different photographic archives, partial databases and websites, which have been supplemented with more detailed and useful information.

Working methodology

Through the history, many works have been already done and published, to catalogue and organize the different techniques and materials used along the history of photography and cinema. Nevertheless, many technical information on film sensitometry and emulsions has been lost and even if some efforts have been made to create dataset collections and catalogues, very few works are open source and have been published (Plutino A., Rizzi A., 2020).

Starting from this need, different existing databases have been merged and different sensitometric and technical information about films have been added, to create a unique open source database available for every researcher.

The proposed work has been developed in 4 different steps:

1. Preliminary analysis of the films collected by R. Gschwind in *Historische Kleinbildfilm Datenbanke* archive, then updated with more information included in B. Flueckiger's database *Timeline of Historical Film Colors* and with the work of N. Mazzanti (Mazzanti, 2009).
2. Creation of a unique identification code for each catalogued film, to combine and collect all the information related to every indexed material. The code is based on the leading features of the film, as explained in the following section.
3. Implementation of a website to share the collected material, with a main goal: the creation of a public and free database always evolving and updating with new information. HTML/CSS/JS were used as coding languages.

Results

The data processing and development process were divided into four main steps.

Preliminary analysis

The first step consisted in the coherent reorganization of the collected material and was possible thanks to the creation of a first simple database in Microsoft Excel. The films were initially divided by brand and a table was created that listed the significant fields of each film (figure 1). Due to the lack of information available, not all fields could be completed.

code	PCNAGFAC1
name	Agfacolor CN 17 (Universal)
date	1956-1975
origin	Germany
photo/movie	photo
type	CN
colouring principle	
ISO	40
grain	
pose latitude	f 8-2,8
contrast	
format	
n° camere films	
soundtrack	
use	

Fig. 1 – attribute's table

Additional research

The research for useful information and technical and physical characteristics about the films led to the collection of attached files of various kinds, including photographs (mainly from the database created by Rudolf Gschwind), technical datasheets and sensitometric graphics useful for defining the qualitative aspects of a film such as exposure, wavelength of the dye used, spatial frequency and spectral density of the dye.

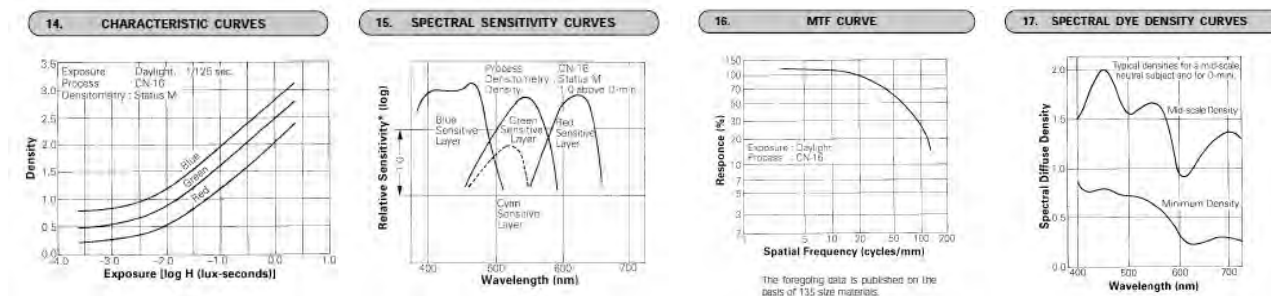


Fig. 3-4 –Sensitometric graphics of Fujicolor Superia 100

Identification code

A unique identification code to define each film was created, as they often have long and similar names. The attached files were collected in folders, named by this code. The unique nine-character code summarizes the main characteristics of each film: the use for photo (photo = P) or video (movie = M); the type of film, i.e. color positive (CP), color negative (CN), color reversal (CR), or the term negative-positive (NP) for films that have both positive and negative version; the production company, indicated by the first three letters of the name (for example Kodak = KOD); and three alphanumeric signs indicating the model of the film itself. Developing a code that referred to the film model was not easy due to the extreme ease with which identical codes could be created.



Fig. 2 – exemplum of code creation

Website

The most important step, however, was the creation of a website containing the proper database, created primarily to make the results of this research available to the community of restorers, archivists and professionals in the field of film restoration. The aims were to create a database that is public and free of charge, useful for promoting research and the development of new knowledge. It also claims to become a place for sharing technical information and it invites the user to become a participant in the project himself. The proposed framework wants to promote the exchange of material in order to encourage the sharing of knowledge in film restoration. The creation of this platform is also placed as a base for growth and integration with future studies as development of sensitometric analysis and scientific investigations on new materials. The site, renamed Photo FiRe - *Film Repository for Digital Restoration* - and available both in Italian and English, is organized in a *Home page* from which it is possible to access the sub-sections *About us*, *Archive*, *Help us* and *Contacts*. The structure of the site is visible in figure 3.

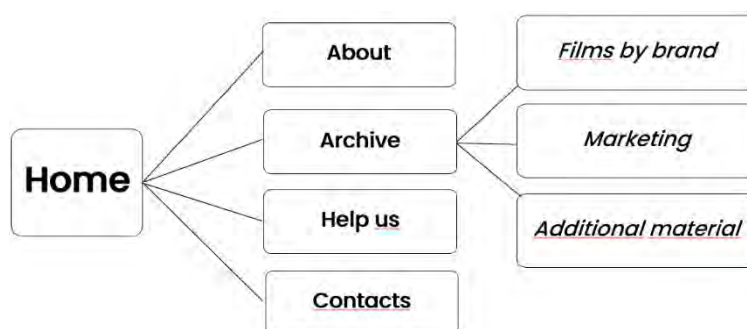


Fig. 3 – website structure

Notably, the *Archive* section is the backbone of the site as it contains the main products of research such as films and technical data. Currently the section contains a further subdivision by brand of films with their respective characteristics and folders containing the attachments, linked to these ones through the code. In addition, and unrelated to the singularity of a specific film, there are sub-sections dedicated to marketing, advertising and additional material. An outline of the structure of this section can be seen in figure 4.



Fig. 4 – archive structure

The possibility of involving other subjects in the research and creation of the archive, is underlined in the *Help us* section, which is dedicated to anyone in possess of material useful to enrich the database: collaboration is very simple and takes place through a form compilation. There is always a control procedure for submitted material prior to publication.

Conclusions

The presented work is therefore developed around the creation of a single large technical database that collects the historical, physical and sensitometric data of the films, to be used as a starting point for such studies. The researches led to the cataloguing of 457 films, each one provided with useful specifications and many of them also with attachments, collected in 161 folders including photographic images, illustrative sheets, links to useful sites or sensitometric graphs.

However, this study was not free from problems, such as the difficulty in finding technical data, both online, but also in the archives of the production houses, inexistent or often inaccessible.

The scarce availability of public archives led to various gaps with the consequent impossibility of attributing a structured code to all films. The current research lays the basis for a future development of the project, i.e the creation of a real relational database, programmed through PostgreSQL, to make the search and download of the material easier and more immediate. First of all, the realization of this website wants to provide an access point for the sharing of knowledge, a key aspect in scientific research. The archiving and classification of any kind of material are also fundamental activities in the field of Cultural Heritage, not only to maintain a trace of the past, but also to support the activities of restoration and conservation itself.

Bibliography

Busche, A. *Just Another Form of Ideology? Ethical and Methodological Principles in Film Restoration*. *The Moving Image*, vol 6, no 2, 2006.

Flueckiger B. *Timeline of Historical Film Colors*
<https://filmcolors.org>

Gswind, R. *Historische Kleinbildfilm Datenbanke*
<https://www.bilderdienst.ch/Filmidentifizierung>

Mazzanti, N. *Cinema Colours, Now and Then*, ICA_Belgium Colour Symposium, Gent, 2019.

Plutino A, Rizzi A. *Research directions in color movie restoration*. *Coloration Technology* (2020).

Digitizing Archive Film: Image, Information and History

Manuel Goetz¹

¹owner-proprietorship, <http://www.inherent-light.fr>

Contact: Manuel Goetz, manuel@inherent-light.fr

Extended Abstract

My approach bridges theory with practical observation and scholarship with technology. Being primarily conceptual, I suggest an altered *dispositif* of film digitization. Generally, I conceive these ideas as basis for further development by the academic and film technicians' communities. Appropriating highly valuable existing research already conducted in the field, my research suggest further experimentation with the available technologies of film digitization.

Since the heydays of the Digital Intermediate system of the 2000s, the image quality within post-production and thus film digitization, which was borrowing much of its technology, progressed drastically. Major developments in these fields are rooted in the efforts of private companies like Kodak (most notably its Cineon data format and workflows appropriating it) or ARRI (think of the ARRICUBE-concept and its linked scanning and re-exposure systems), as well as more recent efforts of communities like the Academy of Motion Picture Arts and Sciences and their ACES color encoding system. In fact, the very inception of such developments can be found in the invention of the CCD-Sensor.

With film restoration constantly having to re-invent and re-appropriate technology rooted in post-production, how can we address these technological developments to the core authorities of film preservation – the propagation of the film apparatus and the entirety of the spectacles it produced? How can we distinguish the different natures historical analog film images and contemporary digital images contain? And where are we to position film archiving within accelerating technological progress (in the film industry but also the cultural sphere as a whole)?

In the field of film digitization, technological implementation has been supported by several research projects, some of them still well and alive today. Concepts along these lines have been discussed by practitioners like Jim Lindner in his FILMIC project (where he suggests methods of multi-spectral film scanning), or most notably Barbara Flückiger's ERC project *Film Colors*, and has found technological implementation, as early on as in Kodak's DICE technology, and their early experimental scanning methods of reversal films. Beyond that, it is clear that in other forms of art restoration (think of paintings or sculptural objects) similar approaches have been in use for a long time.

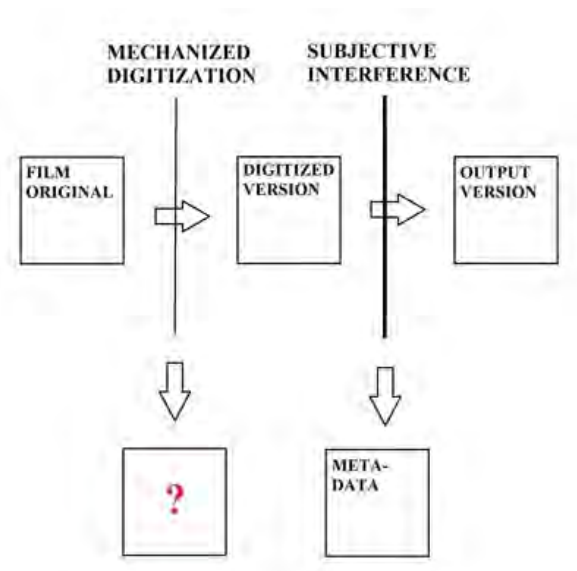
Thus, we can generalize 4 assumptions about the current principles of analog film digitization as a starting point:

- The concept is as old as the CCD-sensor
- The employed digital technology is largely shaped after its presumed predecessor, analog film
- Its tools are derived from film post-production
- The visual quality of contemporary scans is in most cases sufficient for film restoration purposes

Following on from there, my contribution tries to offer a more holistic reading of the matter at hand: In linking the technology to concepts of hermeneutics, the practice of interpreting texts through the use of its own symbols and elements, and methods of media archaeology, I suggest to employ the object's internal characteristics to decide for its own further preservation, thus also a more informed image restoration. I advocate an empirical analysis of structures with the analytical qualities of the film scanner or any other imaging technology that may be about to come.

I suggest a different nature of historical film, in its universality of object, memory, culture, art and technology, and not purely an entertainment device. I suggest to focus on the approach of using film digitization tools to extract information that surpasses the entertainment logic and thus exceeds audiovisual information.

Digital technology could be employed in a fuller variety and not just in its single incarnation as a tool for imaging. The aim of film digitization could therefore not just be an effort of (re)production, but one of information extraction, of analysis, of vagueness, of research – with the aim of making a statement about a historical existence, in the tradition of the material sciences.



As illustrated above, the metadata resulting in the mechanized digitization (the act of film scanning), I suggest, should be treated equally to the manually chosen and interpreted metadata resulting from the subjective interference with the digitized version en route to the final output version.

I argue that it is essential for future film restoration to acknowledge and employ this surplus of information. I envision film scanning to strive beyond the capture of an image's sheer content and move towards the use of the historical information it contains. I believe that, having achieved a certain state of technological progress appropriate for a film's aesthetics, future technologies in film digitization need to secure also the sculptural and thus further the bibliographical qualities of the sample in question. I claim that this second pass does not necessarily need to produce aesthetically interpretable images.



To illustrate this concept a more clearly, I inserted here a scan from my work practice at ARRI Media film restoration. It was calibrated for image content (which became better visible in images following this one). But the frame contains much more than just image content:

handwritten markings that are barely visible, indication of wet and tape splices as well as tape perforation repair.

However the scanning apparatus intends a use that focuses purely on the photochemical film image's content, and not on the sculptural, mechanical and other characteristics the film object carrier may contain. Alternative calibration of the scanning machine would have brought to the fore more clearly these mechanical markers of time that have been engraved through previous utilization – up to a point where they would become interpretable not only by the human eye, but also through machine reading, further simplifying the creation of sets of metadata of historical information.

Why do I believe these are efforts worth undertaking?

- Because it is one useful way of distinguishing archival images from other “timeless” digital content, content of a “no-time”, that is produced everywhere today.
- Because it provides context for presentation: Additional technical information can be used by curators for public contextualization and distribution.
- Because appropriating the internal information available to us through the object itself counteract the rapid obsolescence of human knowledge around old analog film practices.
- And finally, because it enhances the political position of film archives in fostering their knowledge production of objects from the past.

Bibliography

Ajò, D. *et al.* (2019) ‘The Colored Chemistry’, *Cultura e Scienza del Colore - Color Culture and Science*, 11(02), pp. 07–13. doi: 10.23738/CCSJ.110201.

Bideaux, K. (2019) ‘Millennial pink: gender, feminism and marketing. A critical Analysis of a color trend’, *Cultura e Scienza del Colore - Color Culture and Science*, 11(01), pp. 82–89. doi: 10.23738/CCSJ.110110.

Wyszecki, G. and Stiles, W. S. (2000) *Color Science: Concepts and Methods, Quantitative Data and Formulae*. 2nd edn. Hoboken, US: Wiley.

Artinón-Torres M. and Killick D. (2015). "Archaeological Theories and Archaeological Sciences" *The Oxford Handbook of Archaeological Theory*. Vol. 56. Oxford: Oxford U Press

Croci S. *et al.* (2017) "Advanced tools and framework for historical film restoration" *Journal of Electronic Imaging* 26.1 (2017): 1-11. Web.

"Editorial: FILM PRESERVATION: A Critical Symposium." *Cinéaste* 36.4 (Fall 2011): 1. Print

Flueckiger B.(2016) "Color and Subjectivity in Film." *Subjectivity across Media. Interdisciplinary and Transmedial Perspectives*. New York: Routledge, pp. 145-161. Print.

Fossati G. (2011) *From Grain to Pixel The Archival Life of Film in Transition*. N.p.: Amsterdam U Press, Print.

Horwath A. (April 2017) "The Old Life. Reframing Film "Restoration": Some Notes." *Journal of Film Preservation* 96: 27-33. Print.

Lindner J. and Marc J. (September 2015). *FILMIC – A New Approach to Film Preservation. Confidential Media Matters LLC*.

Colour Photography and Film:

Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials

Parikka J. (2012) *What is media archaeology*. Cambridge: Polity Press. Print.

Pescetelli M. (2010) *The Art of Not Forgetting. Towards a Practical Hermeneutics of Film Restoration*. Thesis. University College London. N.p.: n.d. Web. 10 Feb. 2016.

Towards a Standardised Terminology for Photographic Materials in The Netherlands

Kayleigh van der Gulik¹, Magdalena Pilko¹, Martin Jürgens², Sanneke Stigter³, Clara von Waldthausen³

¹Stichting Behoud Moderne Kunst (SBMK)

²Rijksmuseum

³University of Amsterdam (UvA)

Contact: Magdalena Pilko, m@pilko.nl

Extended abstract

Keywords: terminology, photography, Dutch, standard

Introduction

In Dutch museum collections the technological specifications of photographic objects do not follow a common standardised terminology. Especially in the case of contemporary photography, a variety of terms and techniques, often translated from English or deriving from brand names, coexist at the expense of clarity. This can be an obstacle to correctly identifying and preserving these objects. A terminology working group has been formed to improve this situation; it is part of ‘Project Collection Knowledge 2.0 / Photography’, a three-year research program on the preservation of photographic objects in Dutch collections initiated by the Dutch Foundation for the Conservation of Contemporary Art (SBMK) in collaboration with the University of Amsterdam (UvA) and the Cultural Heritage Agency of the Netherlands (RCE)¹. A new standard terminology can improve the understanding of photographic objects in collections, clarify preservation needs and contribute to the overall professionalisation of communication relating to photographic materials in the Netherlands.

The working group

The SBMK Photography Terminology working group consists of nine members including photograph conservators, conservators of contemporary art, registrars and art historians. Over the span of half a year, the working group met eight times through digital one-hour meetings. The meetings were used to divide up work and discuss different viewpoints on individual terms. Between meetings, digital preparatory and follow-up work was done. Two members formed the group’s informal secretariat and worked an estimated total of 70 days. This pensum does not take into account that the working group benefited considerably from previous work carried out by the Rijksmuseum outside the scope of this project.

Creating a workflow

First, an inventory was made of the terminology already present in the registration systems of the four museums that participated in the workgroup. The collected terms were divided into six main categories: photographic processes, photomechanical processes, digital printing processes, finishing techniques, materials, and forms in which the processes are used, such as, for example, ‘collage’. The final list, which is meant to organically grow in the future, currently contains 370 terms.

¹ Participating museums are: the Amsterdam Museum, the Museum Boijmans Van Beuningen, the Bonnefanten Museum, De Domijnen, the Frans Hals Museum, De Hallen, Het Nieuwe Instituut, Huis Marseille, the Kröller-Müller Museum, Kunstmuseum Den Haag / Fotomuseum Den Haag, Stichting Nationaal Museum van Wereldculturen, Rabo Kunstcollectie, RCE-kunstcollecties and the Stedelijk Museum Amsterdam. The National Archives, the Nederlands Fotomuseum, the Netherlands Institute for Conservation+Art+Science+ (NICAS) and the Rijksmuseum participate as advisory partners.

An Excel sheet was designed to give the terms a hierarchical structure and allow group members to record their thoughts and opinions. It was shared with working group members via an online platform.

Each term was first provided in English, followed by the preferred Dutch term, possible brand names and a definition of the term. Possible non-preferred terms, synonymous ‘trivial names’, were listed as well, since they may be frequently encountered in the literature (Fig. 1). Sources were provided for definitions and process names. To keep the document manageable, editing rights for participants were limited. Exceptions to this principle were only granted for the purpose of voting on different terms in a questionnaire in which group members could express their approval, disapproval, doubt or abstention, and in which they could also add comments. Disagreement on terms was settled by following general guidelines that had been set at an earlier stage. As the time needed for discussion far exceeded the time allotted for that purpose, the secretariat took preliminary decisions on individual terms, while taking the comments collected in the questionnaire into consideration. The final list was subject to approval by all of the members of the working group.

Preferred English term	Preferred Dutch term	Brand name	Definition	Trivial name
silver dye-bleach print	zilverkleurbleekdruk	Cibachrome, Ilfochrome, Agfachrome CU 410, Azochrome, Bauchet, Cilchrome, Gasparcolor, ...	Een subtractief kleur-fotografisch procedé waarbij kleurstoffen die in de emulsie aanwezig zijn, ...	c-print
English alternative term	Dutch alternative term			
-	cibachrome (Van Dijk, 2011: 295), zilverkleur-stofbleekprocede (Heyse 1981: 774), zilverpigment bleekafdruk (RKD), zilverkleurbleekdruk (Rijksmuseum)			

Fig. 1. Elements of the working document

Transparency

As mentioned above, each proposed term was supported with one or more references. The starting point for this was a terminology project by the Rijksmuseum's photograph conservation studio that had been carried out prior to the start of ‘Project Collection Knowledge 2.0 / Photography’.

The Getty Research Institute's Art & Architecture Thesaurus (AAT) was the main digital platform used as a source for English terms. Where possible, the Dutch equivalent, AAT-Ned, which is coordinated by the Netherlands Institute for Art History (RKD), as well as a Dutch dictionary were consulted for Dutch terms and their definitions. Specialist literature on photography was also consulted for existing terminology in Dutch: An encyclopaedia on photography and film (Heyse and Schans, 1981) and the well-known handbook by Jan van Dijk (Dijk and Maes, 2019) were particularly helpful. In addition, Dutch art journals such as *BK-Informatie. Tijdschrift voor Beeldende Kunstenaars* were consulted. Working group members occasionally suggested new terms for which no sources could be found, and Dutch printing labs were contacted to learn about the day-to-day terminology of their businesses.

Consistency

To achieve consistency in the final list of terms, the group agreed on a set of guidelines designated to give direction to translations and discussions. A balance often had to be found between the meaning of a term, its Dutch spelling and its practical use. An example is the case of the initially proposed

term ‘inkjet kleurstofthermosublimatiedruk’, in English ‘inkjet dye diffusion thermal transfer print’. It was decided to use the term ‘inkjet kleursublimatiedruk’, a shorter term that is easier to manage and used in practice. Whereas the English term ‘dye’ is ‘kleurstof’ in Dutch, the group decided to consistently use the shorter term ‘kleur’ instead for all terms where this issue played a role, based on common language amongst the group members. The word ‘thermo’ was also omitted as it is redundant, since in this process the sublimation of dyes is not conceivable without the help of heat.

Another application of the guidelines relates to brand names, which are sometimes used as synonyms for photographic processes. These were always distinguished from process names and recorded separately. For example, ‘Cibachrome’ is listed as a brand name, and it was decided to use the more generic ‘silver dye bleach print’, in Dutch ‘zilverkleurbleekdruk’, as a process term.

There was much discussion about photograph process terminology. The Excel sheet lists the term for a process in general as well as the term for a process as applied to the object. The latter is particularly useful for labels and entry texts of exhibitions and catalogues. Using the general process term to answer questions, such as “What is on the wall?”, would otherwise lead to long terms, such as ‘Agfacolor process on glass’ or ‘albumen process on paper’. Instead, the list suggests the use of terms for the object itself, such as ‘Agfacolor plate’ and ‘albumen print’.

While these guidelines were helpful to a certain extent, they could not always provide logical solutions to terminological issues that were encountered during discussions. In these cases, the working group members relied on their own expertise and a certain sense of common language usage. The diversity of professional and linguistic backgrounds of the working group members proved particularly helpful in this respect.

Implementing the proposed standard terminology

The terminology will be introduced in workshops on the identification of photographic materials for registrars and collection managers that form a part of SBMK’s ‘Project Collection Knowledge 2.0 / Photography’. We hope that the terminology will subsequently be used to describe photographic objects in their collections.

In addition, the list of standard terms will serve as the basis for a follow-up working group on the implementation of the terminology in museum registration systems. Finally, the terminology will be applied in a digital identification tool that is being developed as part of the project and that will be made available online. The overall goal is to make the list available to all institutions willing to embed the standard terminology in their registration systems.

Preliminary conclusions

The SBMK Photography Terminology working group has not yet completed its task. The following points may be interesting for similar projects:

- Careful planning of the entire process is important, as considerable time may be required.
- Transparency in decision-making processes and choice of sources could be beneficial for similar projects in the future.
- Continuous input and feedback from different stakeholders in the working group are crucial for acceptance of the proposed standard terminology.
- Efficient implementation measures need to be considered to ensure the use of the new standard terminology in practice.

- It is important to find a larger context for the standardised terminology. In the Netherlands, for example, the RKD organises the Dutch AAT, and gaining their support for the new terminology will prove to be essential for its implementation in museum registration databases.

Bibliography

Art & Architecture Thesaurus® Online. Getty Research Institute. (2017) Available at: <http://www.getty.edu/research/tools/vocabularies/aat/> (Accessed: 12 May 2021).

BK-Informatie. Tijdschrift voor Beeldende Kunstenaars, 3 (2010).

Dijk, J. van and Maes, H. (2019) *Handboek Herkennen Fotografische en Fotomechanische Procedés*. 2nd edn. Leiden: Primavera Pers.

Heyse, P. and Schans, J. J. van der (eds.) (1981) *Foto en Film Encyclopedie*. 4th edn. Amsterdam: Focus Elsevier.

RKD. Netherlands Institute for Art History. (2020) Available at: <https://rkd.nl/en/collections/services-tools/aat-en> (Accessed: 27 January 2021).

The Autumn Colours of Sound: Reading the Records of Old R2R Audio Tapes of the 70's

Maja Kostadinovska

¹National and University Library St. Clement of Ohrid – Skopje, Conservation and Restoration Laboratory

m.kostadinovska.nubsk@gmail.com; m.kostadinovska.nubsk@outlook.com

Abstract

This short study concentrates preservation issues on old traditional open reel-to-reel (R2R) audio magnetic tapes in a special collection “*Struga Musical Autumn*” held at the National and University Library in Skopje. Although all audio tapes have been stored for a long time inadequately under inappropriate local environmental conditions, they are in a relatively good condition. The most common damages found for the magnetic tapes are primarily of physical nature or mechanical damages, but some tapes also exhibit chemically related damages. The work presented here can serve as a cross-study for comparison of the same or similar formats to facilitate an understanding of preservation issues to be prioritised.

Keywords: Reel-to-reel; magnetic audio tapes; analogue technology; preservation; handling and storage; library.

Introduction

Despite the magnetic technology invention in 1928, reel-to-reel (R2R) audio recording tapes were most popular analogue storage media in the 1980s, and today as most prominent carrier media for digital audio archiving in libraries they re-establish a specialist thread in the 21st century. Early open-reel formats came into use around 1970 for home recording, while several professional reel-to-reel formats were developed and used as analogue storage media until the late 1970s (Schüller, 2008).

Tackling the challenges in managing sustainable preservation strategies for open-reel magnetic audio tapes in a library is not uncommon (Van Bogart, 1995). The intrinsic factors that affect these media, which staff cannot control, are the physical components and variation of the manufacturer's quality of the purchased tape and the future availability of system technology for playback. However, these materials are extremely vulnerable in handling and their preservation state is highly dependent on the quality of the storage conditions (Schüller, 1986). High humidity levels and high temperature can enhance the deterioration process, but the type of the damaging process will depend mainly on the composition on the magnetic tape and the stability of its components.

Magnetic tapes are composed of two layers: the *base film* and the *magnetic layer*. The **base film** known as the pigment binder substrate, which is the carrier for the magnetic layer can deteriorate very fast in time (for example, cellulose acetate base films shrink and become brittle with ageing) or it can be chemically very stable (polyvinyl chloride or polyester base films). The **magnetic layer** contains magnetic pigments mostly as powdered iron oxide particles ($\gamma\text{Fe}_2\text{O}_3$), which are bound together with lubricants onto the tape. A common preservation issue with the magnetic layer is called - instability of the magnetic particles/pigments, which occurs as a result of hydrolysis or oxidative decomposition of the pigment binder (irreversible process) in uncontrolled storage conditions and is characterized with signal loss, i.e. noise with instantaneous loss of the recorded audio signal or error in reading data on the magnetic tape. This is especially noticed with the polyester base films.

While this study concentrates on traditional magnetic audio tapes, the preservation issues described are also more or less valid for video, audio cassette and similar analogue magnetic media (Schüller, 2008; Casey 2007).

In general, most common damages found for audio magnetic tapes, which occur due to inadequate handling, inadequate ambient storage conditions, and ageing can be classified in three main categories:

- **physical or mechanical damages** such as tape pack problems (cinching, curling, flange pack, slotted ubs, windowing, popped strands, spoking, stepped pack and others);
- **chemically indicated processes** such as SBS (Soft Binder Syndrome), SSS (Sticky Shade Syndrome) and LoL (Loss of Lubricant), which includes formation of organic acids in polyester-based magnetic tapes causing instability of the magnetic particles or the so-called VS (Vinegar syndrome), which includes formation of acetic acids in acetate-based magnetic tapes, which cause also deformation of the base film carrier – the substrate;
- **biological damage** such as mould development, insect and pests attack and/or their excretions (enzymes, urine, etc.).

Description of the materials used in the study

The present work is a collaborative initiative, which concentrates preservation issues on old traditional R2R audio magnetic tapes in a special collection “*Struga Musical Autumn*” kept at the National and University Library in Skopje. The collection represents a corpus of unique oral and musical achievements in the musical, scientific and cultural field in the country and beyond. All audiotapes are ¼ inches open-reels, mostly on a polyester film. The collection includes eighteen 5” (BASF, AGFA, SCOTCH and off-brand products) and two 7” (SCOTCH 3M) standard long play audio tapes, but also six non-standard 5¾” (SCOTCH 3M) audio tapes (Tab. 1). Some audio tapes are difficult to identify as the original storage container is missing, but according to the recorded material all date from mid-1970s to 1980. The most characteristic types of old R2R audio magnetic tapes found in the collection are presented in Fig. 1.

Tab. 1 – Quarter-inch (¼”) track formats of open reel-to-reel audio magnetic tapes from “Struga Musical Autumn” collection

Cat. No.	Signature	Producer Name	Base Film	Reel Size		Total Items in the Collection
				(cm)	(in)	
1	M A3 13 M A3 20 M A3 21 M A3 22 M A3 23	Off-brand	Unknown	12,7	5”	5
2	M A3 8 M A3 9 M A3 10 M A3 11 M A3 12 M A3 15	BASF	Polyester	12,7	5”	6
3	M A3 14 M A3 17 M A3 18 M A3 19 M A3 25	AGFA	Polyester	12,7	5”	5
4	M A3 1 M A3 2	SCOTCH	Polyester	12,7	5”	2
5	M A3 3 M A3 4 M A3 5 M A3 6 M A3 7 M A3 16	SCOTCH 3M	Polyester	14,8	5¾ ”	6
6	M A3 24 M A3 26	SCOTCH 3M	Polyester	17,8	7”	2

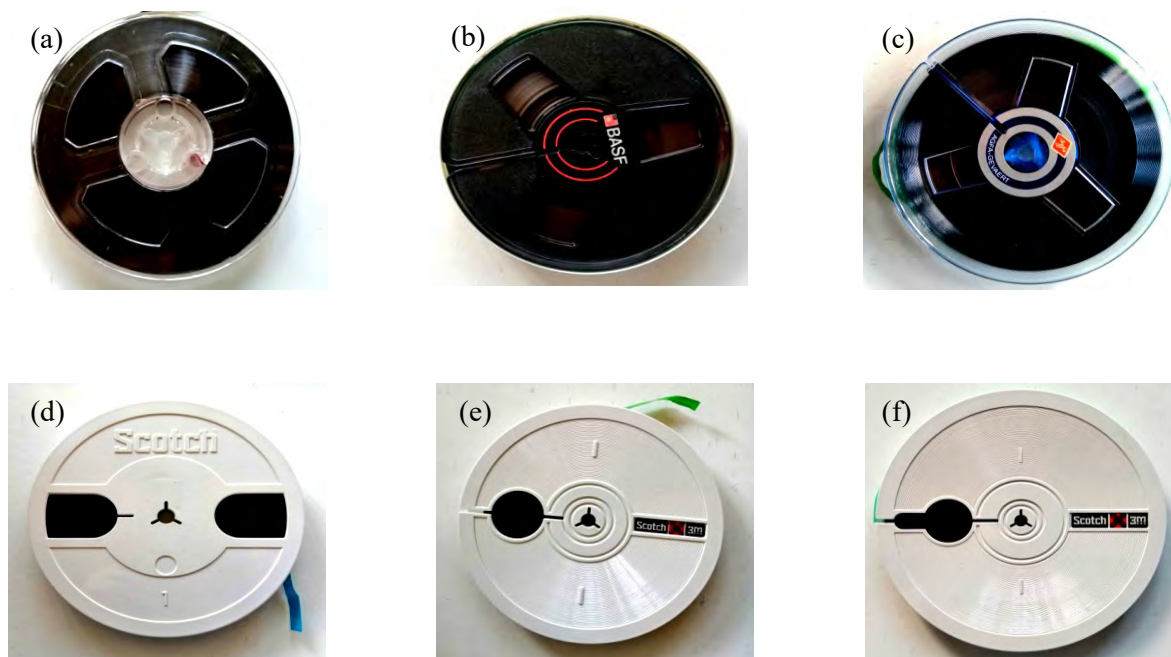


Fig. 1 – The most characteristic types of old R2R audio magnetic tapes in the collection starting from the smallest to the largest (left to right): (a) 5" (off-brand); (b) 5" (BASF); (c) 5" (AGFA); (d) 5" (SCOTCH); (e) 5 3/4" (SCOTCH 3M) and (f) 7" (SCOTCH 3M)

Preservation issues

The most common preservation problems for the open R2R audio magnetic tapes are found due to poor handling, poorly maintained equipment, and poor storage conditions. In general, the condition of the audio magnetic tapes in the collection is good.

Physical damages (50%) include tape pack abnormalities such as edge curling, slotted hubs, popped strands and flange pack (Fig. 2). In most cases, the condition of the R2R audio magnetic tapes worsens due to pre-listening of the magnetic tape with improperly maintained audio equipment or as a result of unprofessional handling during their use, i.e. improper winding of the reel, which causes damages the audio recordings by unevenness (i.e. protruding edges and rings on the tape).

A small part (19%) of the polyester film tapes exhibit a chemically related deterioration process known as Soft Binder Syndrome (SBS), which includes SSS [Sticky shade syndrome] and/or LoL [Loss of lubricant] - loss of lubricants, such as sticking, squealing, and abnormal shedding during playback, which occurs because of oxidative decomposition (hydrolysis) of the binder and loss of lubricants from the substrate (Fig. 3). By-products of this hydrolytic decomposition are organic acids, which further accelerated the process and attacked the magnetic particles (instability).

Another concern with the collection was the particulate contamination observed, such as dust and accompanying paper material and an acidic odour, which is not an unpleasant odour, and occurs as a result of the natural decomposition of the medium - polyester tape under the influence of environmental factors. There was no presence of biological damages as mould, insects or pests i.e. their action or secretions throughout the collection, except for only one magnetic tape.

The presence of signs of liquid contamination throughout the collection such as stains, discoloration of the plastic roll in which the magnetic tape is placed was not observed. In most items, it is noticed that the end of the magnetic tape is not attached to the roll and it unwinds, which can cause physical damage during handling or removal and placement of the material from its primary protection - the original packaging.

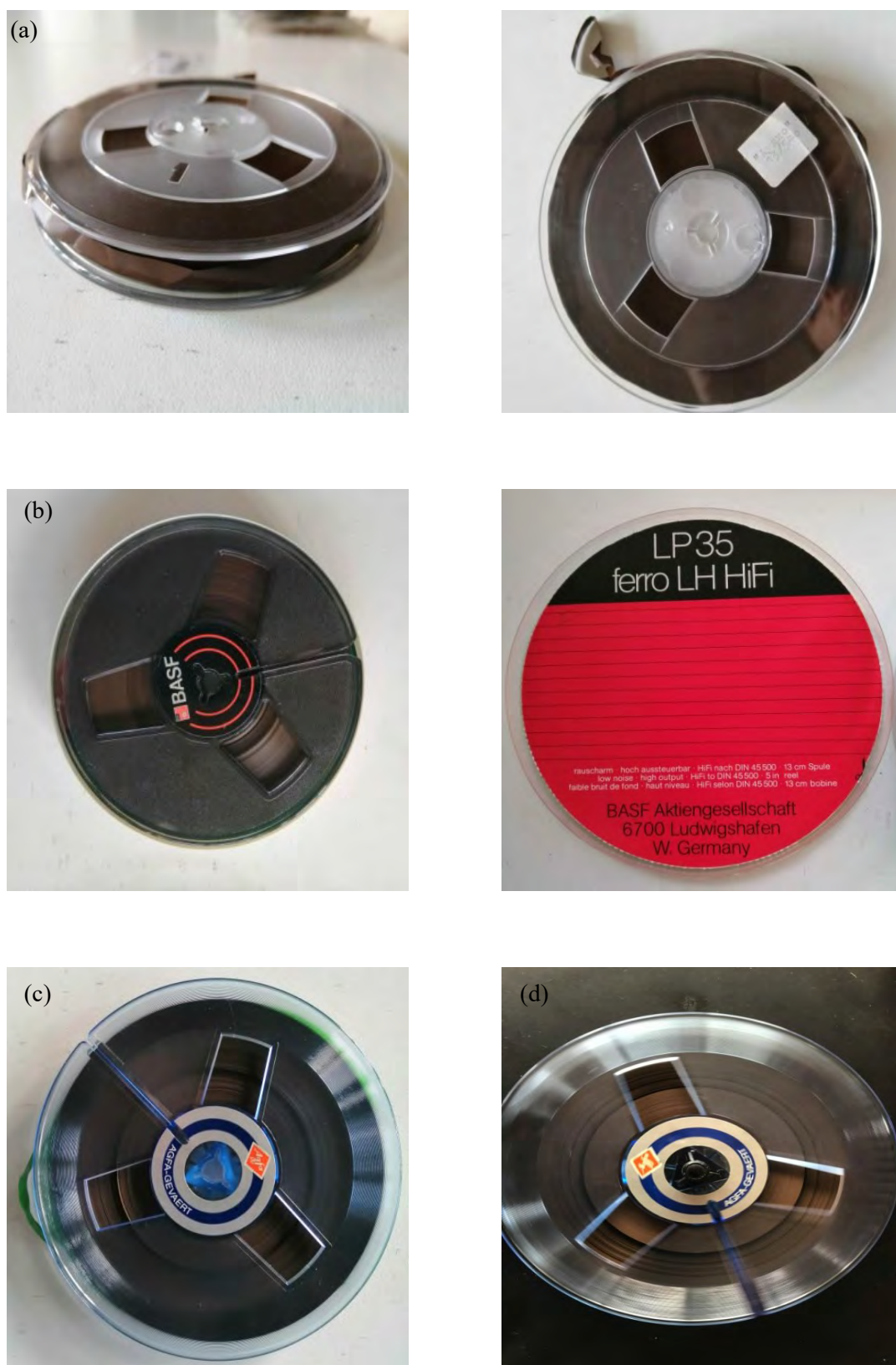


Fig. 2 – Physical damages (Tape Pack problems): (a) Edge Curling (M A3 22); (b) Slotted hubs (M A3 9); (c) Popped strands (M A3 17) and (d) Flange pack (M A3 14)

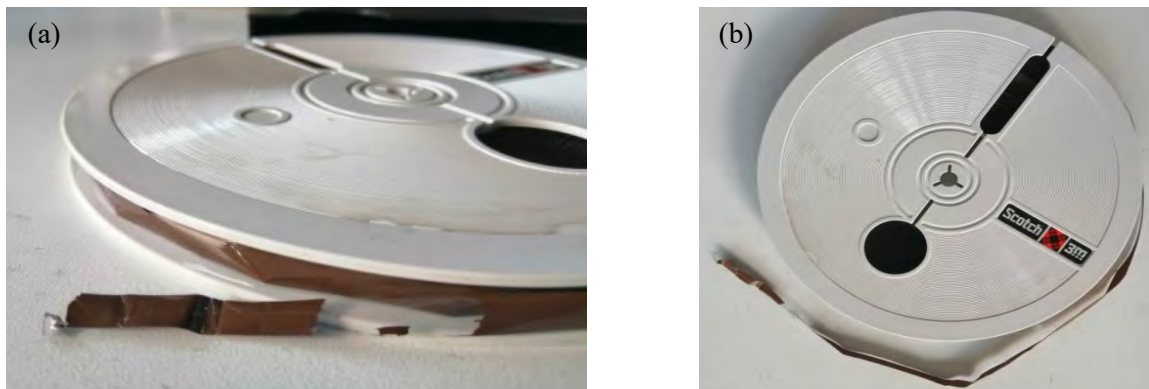


Fig. 3 – Chemically related damages (SBS, SSS, LoL, instability of magnetic particles): (a) 5"(off-brand) and (b) 5¾" non-standard (SCOTCH 3M) and 7" standard (SCOTCH 3M)

Conclusion

Finally, the work presented here can serve as a cross-study for comparison of same or similar formats to facilitate the understandings of priority preservation issues. In conclusion, by observing certain standards for care and limitation of the access to the phonetic materials, i.e. the usage frequency or by providing multiple copies for patrons, libraries can control and prolong their collection's life-time for more than only a decade.

Bibliography

Casey, M. (2007) 'FACET - The Field Audio Collection Evaluation Tool: Format Characteristics and Preservation Problems Version 1.0', *Trustees of Indiana University*, pp. 1–88.

Schüller, D. (1986) 'Handling, Storage and Preservation of Sound Recordings under Tropical and Subtropical Climatic Conditions', *Restaurator* 7 (1), pp. 14–21. doi: 10.1515/rest.1986.7.1.14

Schüller, D. (2008) 'Audio and video carriers: Recording principles, storage and handling, maintenance of equipment, format and equipment obsolescence', Boston G. (eds.), *EU Commission Project TAPE (Training for Audiovisual Preservation in Europe)*, pp. 1–19.

Van Bogart, J. W. C. (1995) 'Magnetic Tape Storage and Handling: a Guide for Libraries and Archives', *the Commission on Preservation and Access and the National Media Laboratory*, Washington, DC, pp. 1–42.

I've Just Seen A Face: Preserving Photographic Memories and Hope Following a Disaster

Debra Hess Norris

Department of Art Conservation, University of Delaware USA

Dhnorris@udel.edu

Extended Abstract

Keywords: recovery, photographic materials, surface cleaning, fire-damaged, disasters

During the first year of study, ten graduate students in the Winterthur/University of Delaware Program in Art Conservation are introduced to the preservation of photographic materials from daguerreotypes to digital prints. Coursework, referred to as “blocks” in our curriculum, has focused on fundamental issues, including the value, significance, examination, analysis, treatment, and preventive care associated with photographic materials

In addition to this core content, recent photograph conservation blocks have involved the treatment and care of large collections of severely damaged photographs. This has included the rehousing of an archive of color slides and dye diffusion transfer images documenting the work of fashion designer Steven Sprouse threatened by aggressively deteriorating PVC enclosures and the preservation of a collection of undocumented portraits of African American subjects damaged by mold growth and excessive staining. Years ago, we focused our efforts on the recovery of photographs salvaged from a tragic house fire near Columbus, Ohio where three, young, beautiful boys and their beloved grandmother lost their lives, and the stabilization of photographs from catastrophic floods in Wimberley, Texas.

I am grateful to the many students, faculty, staff, and others who worked evenings and weekends on these projects, generously sharing their knowledge, skills, and commitment to excellence. This is *their* work and they should be commended. It is difficult to describe our sadness in dealing with the fire-damaged materials especially. Working together we found the emotional strength to proceed. There were many tears... and yet our commitment never wavered.

The notes below summarize general observations and techniques deployed during both recovery processes, including approaches to surface cleaning using dry and wet methods and basic approaches to eliminating odor from fire-damaged materials.

Examination and General Observations in Recovery of Large Collections of Damaged Photographic Prints

- The extent of treatment must be considered during examination and discussed with the owner or caretaker where reasonable. Following tragedies such dialogue may not be possible.
- In emergency recovery, full cosmetic reintegration is not a reasonable or realistic goal.
- Conservators must find the appropriate balance between the extent of treatment and the time available for the recovery of a large collection, but they must always follow ethical guidelines.
- As work progresses, conservators will become more confident and systematic in their approach. In doing so, improved results and a better assessment of the degree of cleaning necessary during a recovery will be realized. If time allows, it may be prudent to reassess the first photographs that were cleaned, as better methods may develop with more experience.

- Each photograph will have aged and degraded differently and demands careful individualized attention owing to its condition and significance.
- When working on a mass treatment within a group of professionals, a clear division of labor is helpful, as is a strong sense of teamwork and shared goals and vision. Treatments should be shared and assessed by others to ensure a fresh perspective and greater precision.
- Selected photographs could be examined microscopically to better assess the extent of damage and treatment efficacy.
- Establish an agreed upon treatment workflow that may be modified selectively. Ensure all materials are organized and tracked with well-labeled boxes that indicate treatment steps and maintain order.

Odor Reduction

- Soot can irritate lungs and skin. Wear disposable gloves when handling the photographs at all stages. These will protect hands from soot and photographs from fingerprints. Avoid making the particulates airborne. Wear a disposable dust mask if the odors are found unpleasant or irritating.
- To minimize smoke odor, immediately remove as much loose soot as possible using soft brushes before individual treatment. Interleave materials to be treated with absorbent papers (blotters, micro chamber, or even poor-quality absorbent papers, for example) and replace interleaving regularly to reduce odor. House photographs in plastic containers that may be vented at the top, where necessary, and store photographs in a well-ventilated room
- Natural zeolites, composed of silica and alumina tetrahedral, are commercially available. They may be used to eliminate odors by placing them in plastic bins with interleaved photographs. Interleaving should be replaced regularly.
- Avoid air fresheners and other materials with “fragrance” added as the damaged photographs may imbibe the freshener smell. Analysis of these materials has not been undertaken.

Dry Removal of Soot and Embedded Debris and Accumulated Surface Accretions

- Small Mars Staedtler erasers cut into triangular shapes may remove or minimize stubborn black marks on reverse of photographs with RC supports.
- Care must be taken not to apply too much pressure on the photograph’s reverse with erasers – highly ferrotyped surfaces may crack locally.
- Microfiber pads, applied dry, work well and efficiently for removing grime from the front of glossy photographs.
- Magic Rub Erasers (block erasers cut into smaller pieces) work well to reduce/remove areas of soot on reverse of photographs, especially edges.
- Kneaded erasers work well for removing accretions and soot near edges where wet treatments are not practical.
- Cosmetic sponges appear to be gentle but can effectively remove significant dirt and grime on all surfaces. These sponges can be rinsed in water and allowed to dry prior to use. Soot sponges are most successful on heavily damaged areas and are generally more effective on the reverse than cosmetic sponges. They also can be cut into shapes that are more easily manipulated and work very well for oily grime. Soot sponges were found ineffective on the obverse, as they readily cling to the gelatin surface.
- Resin-coated papers that had delaminated at their outer edges could be consolidated with methyl cellulose once the surfaces were cleaned of dirt and debris where possible.
- Bamboo skewers can be used locally for breaking up large accretions prior to removal.
- Pencil erasers may be used locally on glossy black-and-white photographs to reduce residual surface dirt that appears cloudy and gray and obscures detail. Care should be taken not to further burnish the surface in doing so. This approach may not be effective with matte-surfaced photographs. Note that the eraser can be abrasive and may leave scratches. Monitor the surface in raking light carefully. Areas that are burnished may be reduced locally by application of moisture with a small brush.

Wet Removal of Soot and Embedded Debris and Accumulated Surface Accretions and Deposits

- Surfaces often may be cleaned with 100% ethanol. If blanching occurs with pure ethanol, try using an ethanol: water (3:1) mixture in order to rehydrate the gelatin. Ethanol/water should be avoided in delaminated/skinned areas on the verso of the RC paper. Also note that the reverse of SX-70 Polaroid's may be sensitive to ethanol.
- Some fire-damaged photograph surfaces (both color and black-and-white) may be very sensitive to moisture and will swell and become tacky. Ethanol (90%) can be useful in minimizing swelling and allowing for modest reintegration of the glossy surface.
- Black marks and soot on the backside of RC photographs may be reduced with ethanol.
- Polyvinyl alcohol (PVOH) sponges, immersed in water and squeezed to remove excess moisture, are effective on the reverse of RC paper. They are typically too aggressive for the emulsion layer.
- PVOH sponges may also be immersed in ethanol, providing an elegant and controllable delivery system to the photograph's damaged surfaces.
- Care must be taken in using water and ethanol (3:1) on burned or melted areas as these solvents may solubilize the dyes in chromogenic color prints, especially cyan.
- Saliva on a small swab can remove locally intractable debris
- It may be more prudent to leave migrated dyes in areas of loss instead of cleaning (solubilizing) them to a bright white that may make the damage more prominent.
- Some of the surfaces will delaminate upon contact with ethanol, but settle down when left alone.
- Soot can be embedded with moisture (water) and can subsequently become more difficult to remove. Dry techniques should precede wet techniques.
- Some matte areas can be reduced by passing over lightly with saliva, then saturating with ethanol.
- Ethanol mixtures can alter time stamps on the reverse of some photographs.

Traditional humidification and flattening approaches from the use of Gore-tex® to multiple humidity chambers were deployed on a large scale for fiber-based prints with great success. Given the numbers of materials, once cleaned photographs were divided into bins for flattening. Students were responsible daily for chamber preparation and oversight. Staying on top of this process was essential as we allowed all prints to dry for 3-4 days with blotter changes.

While some resin-coated (RC) papers from both disasters could be flattened using moisture chambers, most required the use of a dry-mount press at 160°F (71°C). The press was heated to this threshold and then turned off. The prints were placed between silicone release papers, allowed to equilibrate for 30 minutes, and then flattened between polyester web, blotters, glass, and weights. Badly distorted RC materials required repeated processes to allow them to flatten gradually.

While advancing our knowledge in and experience with the treatment of damaged photographs including chromogenic and dye diffusion color and digital materials, these projects allowed us to work together toward a more important goal – helping those in need to preserve their treasured possessions during especially dark and challenging times. As we deal with a continuing global pandemic, the preservation of memory is inextricably linked to healing and well-being.

This often-tireless work affirmed the significance and value of our shared photographic heritage and the pressing need to develop emergency response and recovery procedures that mitigate irreversible damage and loss. Our profession must continue to respond to ever increasing natural emergencies with skill and compassion. During unanticipated crises, our work in the preservation of cultural heritage from archeological artifacts to contemporary color print materials must be grounded in our

ability to connect and collaborate and to share our skills and knowledge openly with others. We must lead — always — with knowledge *and* kindness.

Bibliography

- Albright, G. (1999) 'Section 3.7: Emergency Salvage of Wet Photographs', *Northeast Document Conservation Center*. Available at: <https://www.nedcc.org/free-resources/preservation-leaflets/3.-emergency-management/3.7-emergency-salvage-of-wet-photographs>
- 'A Consumer Guide to the Recovery of Water-Damaged Traditional and Digital Prints', (2007) *Image Permanence Institute*. Available at: <https://lenasalina.files.wordpress.com/2016/08/water-damage.pdf>
- 'Emergency Preparedness & Response', (2020) *American Institute for Conservation Wiki*. Available at: https://www.conservation-wiki.com/wiki/Emergency_Preparedness_%26_Response
- Norris, D. H. (1998) 'Disaster Recovery; Salvaging Photographic Collections', *Conservation Center for Art and Historic Artifacts*. Available at: <https://ccaha.org/sites/default/files/attachments/2018-07/technical-bulletin-salvaging-photographs.original.pdf>
- Norris, D. H., & Lemmen, B. (2016) 'Salvaging memories and building cultural understanding: The recovery and preservation of photographs from natural disasters and armed conflict', *American Institute for Conservation Photographic Materials Group*.
- Robb, A., Lemmen, B., Koch, M., and Hill, G. (2011) 'Summary of Photographic Materials Group Emergency Recovery of Photographs', *American Institute for Conservation Photographic Materials Group*. Available at: http://www.ndl.go.jp/jp/aboutus/preservation/pdf/lec201109_text6.pdf

Color on glass-about conservation and preservation projects of Crystoleum, Autochromes, Agfa Color Plates and Dufay/Dioptichrome Plate photographs (case studies)

Anna Seweryn¹

¹National Archive in Krakow

Contact: Anna Seweryn, aseweryn@ank.gov.pl

Abstract

Color photographic materials on glass are very rare in Polish photographic collections. Due to the fragile base, relatively high price and the historical turmoil that our country underwent during the production and implementation of the first color technologies, these objects are not found in archives or museums, and even if they are present, they are not correctly identified.

My adventure with color photographs on glass begins in 2013, when I receive photograph made in the Crystoleum technique for conservation treatment. The biggest technological problem during the work was re-affixing the image layer which separated from the glass substrate. In order to choose the best adhesive, I made a series of tests for the adhesion and effects of the process of sticking the albumin print to glass, e.g. for photographic gelatin, Klucel G, Tylose MH300, starch paste, Funori, microcrystalline wax, the latter of which, together with the activation of the primary binder by temperature, turned out to be the best application. Despite the long process of conservation, this work proves that objects with a silver image are conservable and their condition can be significantly improved, which is not so obvious in the case of color photographs, where the image is based on dyes.

In 2017, a group of 300 glass negatives after a fire and flooding came to my private studio. While working on consecutive negatives, I found pink-colored glass without image layer. While browsing the objects, I also found a degraded gelatin-silver image layer completely detached from the base. The observation of these two components under magnification allowed to combine them into one coherent whole. The pink discoloration of the glass was caused by the presence of a series of red lines, and at the corners of the glass there were also parts of the remaining components of the additive color screen: intersecting blue and green lines. On the other hand, local red dots can be observed on the gelatin-silver layer, which look like a microbial infection or ink stain. The whole object was identified as a photograph taken in the Dufay/Dioptichrome Plate technique. The glass base and the image layer were protected separately (image in a glass sandwich).

My last and greatest experience with color photography on glass is conservation of the collection of 145 autochromes and Agfa Color Plate photographs (2020). Despite the fact that these works were mainly technical (cleaning, sealing), they were very time-consuming and required a lot of concentration. In the conservation process itself, interesting are the differences between the surface of the glass - the base and the cover glass, the possibility of using classic methods and modern conservation tapes, and the analysis of photochemical damage, often giving the photographic image a new context.

Keywords: Crystoleum, Dufay, Dioptichrome, Autochrome, Agfa Color Plate.

Introduction

In my professional practice, color photography was mainly associated with photographs made by the chromogenic process, thinking about photographs as an object on a paper base or slide. Color objects made on a glass substrate seemed to me to be something incredibly unique and ephemeral. The fragility of the substrate and the vulnerability of the delicate components of the image layer were

factors that could lead to the complete destruction of materials of this type. My experience with color photographs on glass was unexpected. Proceeding with conservation work required recognizing the technique of the object and familiarizing myself with the literature on the subject happily available online or in published form.

Crystoleum

Crystoleum is a fascinating photographic technique in which the means used are intended to create an impression of color through the use of coloring and retouching of a photographic image taken using silver particles. This technique was popular between 1880-1910 and this technique can have many different modifications.¹

Usually in this technology, an albumen print is set from the image side on the cylindrically profiled glass. Then, after drying the binder (usually starch, gelatin, wax, or mixtures of these ingredients) the paper base is removed in a mechanical way using fine-grained sandpaper, which allowed to obtain a transparent image. Before removing the paper backing, the surface is rinsed with warm water. To make the albumen image layer more transparent, it is impregnated with oil, wax, or varnish.² This process required heating the entire photograph, which allows the substance to migrate through the image layer to the glass plate. Immediately after this process, an object is laid on a cold metal plate or stone for quick cooling.³ After the binder is dried, the photograph is retouched with oil paints and colored background is applied to the reverse to give the monochromatic image realistic colors. Then, the reverse side is secured with another piece of glass, profiled identically to the image layer carrier. All elements are connected with a paper border to create an integral object and protect the whole against mechanical, physical and chemical damage. A metal frame also protects the photograph.

The object which came to my studio was relatively small, it had an oval shape and was only 7,5 cm in height and 5 cm in width. In an object, we can extract all the components described above. Both glass plates, although they have a similar shape and size, are made of glass of different thickness and are obtained from different sections of the sphere of a *glass ball* and do not adhere closely to each other (perhaps the back plate is no original, there was no trace of paper border or adhesive). The colored background was made in pastel on paper backing (Fig.1).



Fig. 1 - Components of a photograph made in the Crystoleum technique: photographic image breakdown, colored background, and two profiled glass panes; photo: Anna Seweryn, photograph comes from the collection of the Sosenko Family Collections Foundation.

¹ Harasym, Z. (2005) *Stare fotografie: Poradnik Kolekcjonera*. Warsaw PL: Arkady, p. 93.

² Payne, B. (2011) *The Crystoleum: Bringing the Art of Photo Colourisation into the Home*. Available at: <http://photo-sleuth.blogspot.com/2011/10/crystoleum-bringing-art-of-photo.html> (Accessed: 14.05.2021).

³ Zając, I. (2010) *Nietypowe fotografie-konserwacja i restauracja dwóch portretów*, Notes Konserwatorski, 13, p. 171.

The photograph in question went through the conservation process because the image was unreadable. The damage occurred while the object was moved in wintertime from one building to another without any protective packaging or box. Due to the low temperature, the wax layer on which the image was stuck to the glass base hardened and lost its original flexibility and the image was detached from the glass base. Wax remaining on the glass surface formed a mating effect that makes the content of the image difficult to see. After removing the glass, it was found that the photographic image itself was in relatively good condition. Additionally, the object shows damage typical of photographic materials - years of dirt caused by improper protection and storage of the object, traces of insects and rust, tears in paper elements. The background of the photo, made in the pastel technique, was in a pretty good condition.

The most important part of the planned conservation process was determining the materials and technology to re-stick the albumen image layer to the glass substrate. To check the advantages and limitations of a particular binder I prepared a series of samples-fragments of homemade albumen prints and various adhesive solutions used during conservation processes. I prepared 23 samples using Klucel G, photographic gelatin, starch paste, Funori, microcrystalline wax and other or combination of some of these materials together in percentages from 1 to 5. Sometimes I use one adhesive to prepare the surface of the image and another for sticking the picture to the glass. After placing the samples on the glass substrate, I waited 24 hours and I observed and documented the models in sidelight and transmitted light. The samples were analyzed in terms of the image aesthetics obtained by a given binder and the adhesive strength. The material composition and its effect on the photographic image structure were also considered. The most important thing was to obtain a uniform surface of the image, minimize the presence of air bubbles between the surface of the image and the glass, and good adhesion to the glass. The best results were achieved by photographic gelatin, microcrystalline wax and starch paste. Still, due to the technology of the object and the use of wax paste in its structure, adhesives based on aqueous solutions would not be effective when used in the conservation process. The original wax layer found on the photographic image layer was very uneven, there was a lot of it in places and this excess was mechanically moved to the parts of the image that needed it. The photograph thus prepared was stabilized face down on a glass substrate and subjected to a heating process. The object was heated using tacking iron and Japanese tissue paper and Melinex to protect the surface. An iron was led from the center of the object to the edge to bring out possible air bubbles to the outside. During the process, the temperature was increased up to 60 degrees of Celsius and only a little amount of new microcrystalline wax was added to the object's face. Immediately after the process, the object looked very good, but air bubbles became visible after leaving for 24 hours. The heating process was repeated and then the object was placed in a low temperature so that the wax hardened quickly and that there was no further loosening and bubbles of air. All other elements of the Crystoleum were mechanically and chemically cleaned. The paper border around the object was not recreated because due to the different shapes of the glass plates and the risk of stress, which could lead to a crack. Glass plates were connected only locally with Japanese tissue paper and starch adhesive.

During the entire conservation process the most significant risk was associated with the presence of a glass substrate. If it is damaged, obtaining a similarly profiled glass would probably be impossible, and damage could be possible due to the temperature change applied in the process. After the conservation process the photograph was placed in a special box made of PAT tested materials and the small parts of the original paper border were kept in the small envelope inside these box (Fig.2).



Fig.2. Crystoleum before and after conservation processes;
photo by Anna Seweryn, photo is from the collection of the Sosenko Family Collections Foundation.

Dufay Color/Dioptichrome process

My next contact with a photograph made in color on a glass base came quite unexpectedly. In 2017 I worked on the conservation of 300 glass negatives rescued from the disaster. These photographs had been victims of fire and flooding and were in deplorable condition, protected in their wrappers, often cobbled together and broken. During the processing of subsequent objects, I came across a glass pane devoid of the photographic image layer but with intense pink color. The next day I also discovered a layer of photographic imagery delaminated off the ground. Even at first glance, the two parts of the object had something in common: the size, the shape, and the two longitudinal defects visible in the image are reflected in the discoloration on the glass substrate (Fig.3).



Fig.3. Degraded photograph made in the Dufay/Dioptichrome process;
photo Anna Seweryn, photograph comes from the collection of the Regional Museum in Siedlce.

The observation of these two components under magnification allowed to combine them into one whole. The pink discoloration of the glass was caused by the presence of a series of red lines, and at the corners of the glass there were also parts of the remaining components of the additive color screen: intersecting blue and green lines. The lines go at an angle of about 45 degrees, so they are not parallel to the edges of the image (Fig.4). On the other hand, on the image layer, some red dots can be observed. Although the object is damaged, we can tell from the existing components that this photograph was taken in a color additive color screen process, it is transparencies with a combined

system-where the black and white image sits on top of the color screen on one single glass plate. The technology has been identified as Dufay/Dioptichrome process.⁴



Fig.4. Close-up on a degraded photograph made in the Dufay/Dioptichrome process, visible components of the color screen; photo Anna Seweryn, photograph comes from the collection of the Regional Museum in Siedlce.

The glass base and the image layer were housed separately (image in a *glass sandwich*). Once the object was safe, it was possible to take scans and attempt to process the files. During digitizing and processing the files, it was not possible to see any possible color stored in the photograph. The image itself was not developed, or perhaps even exposed, in a manner suitable for this technique and we are dealing here only with the recording of a negative on a multi-layered, colored substrate.

Autochromes/ Agfa Color Plate

In 2020, I began a project to conserve the autochromes of Jan Zdzisław Włodek. There are 245 objects in the collection and it is the fourth known and the largest collection of autochromes in Poland. These photographs were taken between 1912 and 1930. Jan Zdzisław Włodek was a famous Polish professor of agriculture, ecologist, botanist and philanthropist. He personally exposed and developed autochromes and put on them many notes about the place, time of exposure and content of the image. Włodek used autochromes mainly for work; he showed autochromes during lectures with students. You can mostly find plants and botanical experiments in the picture, but an author also documented landscapes and family life.

The autochrome process was invented by the Lumière brothers in 1903.⁵ Autochromes as other color screen processes on glass they are technologically combining silver technology with dyes (Fig.5). The base of the autochrome is a glass plate on the surface of which a sticky varnish was applied, constituting the basis for a colored raster made of starch grains. Starch was dyed with organic dyes in three colors: orange-red, violet-blue and green, and the resulting free spaces were filled with soot. The colored filter is protected with a layer of varnish made of damara and cellulose nitrate, which protects the water-soluble dyes against damage during the subsequent wet steps of the board production or during post-processing. The next layer, viewed from the substrate side, is a suspension of silver halides in gelatin, which, when reversibly developed, creates a positive silver image. After completing the chemical processes, the entire object was varnished and secured with another glass

⁴ Pénichon, S. (2013) *Twentieth-Century color Photographs, Identification and Care*, Los Angeles, CA: The Getty Conservation Institute, p. 31.

⁵ Lavédrine, B., Gandolfo J-P. (2013) *The Lumière Autochrome, History, Technology and Preservation*, Los Angeles, CA: The Getty Conservation Institute, p. 94.

plate, which was attached to the object along its edge with a tape, usually with a thermoplastic adhesive.⁶



Fig.5. Autochrome photograph with visible *recto* and *verso*; photograph by Anna Seweryn, autochrome held by the Zofia and Jan Włodek Foundation.

Photographs in Włodek's collection were preserved in excellent condition. The images are colorful, sharp and with high contrast. The greatest damage was on autochromes lacking cover glass; there were also a few broken and defaced photographs. Black tapes covering the edge of the object, which are carriers of information handwritten by the author on a given photo, also required reparation. Damage typical of the autochrome technique can be observed: degradation of the silver image layer and green spots and stains - deterioration in the screen caused by migration of the solvent for ex. the final varnish. Typical damage was also the delamination of the image layer from the glass.

The conservation process has focused on cleaning the objects, repairing the black tape, and sealing the objects. For cleaning a typical solution for photographic glass surfaces, ethanol and water half and half, was used. The chemical cleaning process was time-consuming: firstly, it has to be done from both sides, secondly, we have to take care not to get the paper tapes wet (to be precise toothpicks with cotton wool on the edges were used), and thirdly the structure of the cover glass was different than that of the glass base, the glass was more porous, rough and dirt had to be removed from its surface in several stages. All this made this process very long, and time can be estimated estimate it was even four times longer than when cleaning a glass plate negative of similar size, which is essential when you are planning the work. The second phase of the work was to seal the object, taping up the paper tapes or filling them in. The first conservation plan was to use transparent conservation tapes such as Filmolux s23, which were supposed to cover with excess the parts of the black stripes that were falling of. Unfortunately, after one attempt, the aesthetic effect was terrible and in addition, working with transparent tape is quite difficult because it catches dust and has inherent flaws. The plan was revised, and a starch paste and Klucel G in ethanol were used. Where the original tapes were missing Filmoplast P90 dyed black was used. After conservation processes, the photographs were placed in four-laps envelopes and boxes, all with PAT certificates.

⁶ Lavédrine, B. (2009) *Photographs of the Past, Process and Preservation*, Los Angeles, CA: The Getty Conservation Institute, p.77.

While working on the autochromes also photographs taken using the Agfa Color Plate technique were found. Agfa Color Plate was patented in 1908, produced since 1916, and is a technique quite similar to autochromes, with a gum arabic and dextrin in a structure of color screen, without carbon black. One of the typical features of these photographs, apart from technological differences and a different view under the microscope, distinguishes them from autochromes, is the strong green tone of the image⁷ (Fig.6). Some of the Agfa plates are not as green (perhaps a later, improved version of the technique), but have a cooler hue, and at the same time the quality, color reproduction and contrast of these photographs is not as good as with autochromes. When viewing autochromes and Agfa Color Plates under a microscope, in addition to differences in screen structure, one can also see the typical concentric spots. While in autochromes, they are always green, they were always blue on Agfa plates, which means that it is most likely that this blue dye is the most sensitive to solvent.



Fig.6. The photograph was taken using Agfa Color Plate technique - the characteristic green color of the image is visible; photo: Anna Seweryn, the photograph comes from the collection of Zofia and Jan Włodek Foundation.

The conservation processes carried out on the Autochromes and Agfa Color Plate did not interfere with the structure of the objects, but rather focused on the necessary repairs, preparation of the objects for the digitization process and future preservation. An essential part of the work was the preparation of meticulous descriptive and photographic documentation. The photographic documentation was always done in reflected and transmitted light, on a backlight. For the most damaged objects, to determine the most common damage in this particular collection, graphic states of preservation were made.

Conclusion

Working with photographs taken in the first color processes is undoubtedly a privilege for the photographs conservator. Even when we choose the path of minimal interference with the object or its structure does not allow for more invasive work, we can still learn something new, do our homework on forgotten techniques and technologies, and become fascinated by the past development of photography.

⁷ Pénichon, S. (2013) *Twentieth-Century color Photographs, Identification and Care*, Los Angeles, CA: The Getty Conservation Institute, p. 42.

Acknowledgements

I would like to thank Stephanie Ledamoisel, Photograph Conservator at Atelier de Restauration et de Conservator des Photographies de la Ville de Paris, for substantial assistance with the autochrome project.

Bibliography

Harasym, Z. (2005) *Stare fotografie: Poradnik Kolekcjonera*. Warsaw PL: Arkady.

Lavédrine, B. (2009) *Photographs of the Past, Process and Preservation*, Los Angeles, CA: The Getty Conservation Institute.

Lavédrine, B., Gandolfo J-P. (2013) *The Lumière Autochrome, History, Technology and Preservation*, Los Angeles, CA: The Getty Conservation Institute.

Payne, B. (2011) *The Crystoleum: Bringing the Art of Photo Colourisation into the Home*. Available at: <http://photo-sleuth.blogspot.com/2011/10/crystoleum-bringing-art-of-photo.html> (Accessed: 14.05.2021).

Pénichon, S. (2013) *Twentieth-Century color Photographs, Identification and Care*, Los Angeles, CA: The Getty Conservation Institute.

Zajac, I. (2010) *Nietypowe fotografie-konserwacja i restauracja dwóch portretów*, Notes Konserwatorski, 13.

Digital Struggles: from Film Restoration to a Digital Historical-Critical Environment

Serena Bellotti¹, Simone Venturini¹

¹Università degli Studi di Udine

Contact : bellotti.serena@spes.uniud.it, simone.venturini@uniud.it

Abstract

Our presentation is focused on the ongoing reconstruction and restoration of *La battaglia dall'Astico al Piave* (Regio Esercito - Sezione Cinematografica, 1918, 35mm, tinted and toned, film certificate n. 13649 of 01.09.1918, mt 1255), carried out by the University of Udine in collaboration with Kinotealje, La Cineteca del Friuli, Istituto LUCE, Cineteca Italiana, Lobster Films and supported by MIBACT.

To the present day are documented three versions of *La battaglia dall'Astico al Piave*: the 1918 Italian and French Version, both realized by Italian Royal Army Film Department, and a further version, named "Ta Pum", released in 1927 and still in circulation around 1930-1933, likelihood re-edited by Istituto LUCE. The project aims to reconstruct the first Italian edition of 1918 and at the same time give an historical and visual account of the other versions, especially the 1927 re-release.

Restoration and reconstruction are based on film materials collected after a first survey among film archives (and on several non-film materials such as journals articles, archival documents, etc.):

- witness "K": that is, the main reference for the Italian version, retaining the most part of the narrative order, the original intertitles and tinting and toning, including the handwritten information on the color palette printed on the film edge (from Associazione Kinoatelje: 35mm nitrate print on three reels, long approximately 900 mt);
- witnesses "G1" e "G2": two 35 mm fragments of the French version preserved by Cineteca del Friuli (restored 35mm copies from the nitrate prints preserved by Lobster Films);
- witness "G3": a short fragment of the Italian version, preserved by Cineteca del Friuli within a nitrate print of *Da Capodistria a Fiume italiana*;
- witness "RM": a long duplicate negative (1000 mt ca.) with flash intertitles on 35mm safety stock, preserved by Istituto Luce, and likelihood dating back for the image contents and intertitles to both the late 1920s re-release and the 1918 edition;
- witness "MI": 35mm positive fragment on nitrate film preserved by Cineteca Italiana in Milan and close to the 1927 edition.

The aim of our contribution is twofold: on one hand to highlight specific restoration and reconstruction issues (film material description, documentation and analysis; version, editions, re-releases; tinting and toning reconstruction; performative aspects concerning the specific status of film, involving both commemorative and trauma reliving aspects during the screenings); on the other hand to focus on the reloading and reframing of the long-standing and sensitive field of digital research- and educational-oriented critical edition of films, addressed to document the restoration and reconstruction process and give a wider account of the material, visual and cultural history of film as a set of apparatus, discourses, and practices, here proposed through an innovative digital design and environment and following new interdisciplinary approaches.

Introduction

Starting from archival prints, textual reconstruction is made with the help of "edge to edge" and "repro-set" recordings and other non-film materials. The restoration is carried out through the digital intermediate route, then recorded back on film to reproduce tinting and toning through the Desmet method and using as main reference the witness "K". Then the 35mm color print will be scanned to obtain the conformity between, at least, the photochemical and the digital theatrical copies that could not be achieved otherwise. Here, we are going to show our operative methodologies at that present moment, discuss some of the interesting *loci critici* we have found right now and show a very raw concept of our digital environment under construction.

Recensio

The restoration and reconstruction are based on film materials collected after an extensive survey carried out among film archives. The *recensio* revealed the existence of a *tradition* composed by several film elements, or *witnesses*, as they are commonly called in philology.

Witness “K” (the main reference for the Italian 1918 version) is made by a re-editing and assembling two prints of the same first-generation Italian version of 1918 and include also a single shot printed on Ferrania stock, that was released on the market only in the late 1923, a clue which attest a later circulation of the film around the late 1920s. Nevertheless, it retains most of the narrative order, the original intertitles, and tinting and toning. It also includes handwritten information on the film edge about original editing and colour palette coming from the original camera negative.

Cineteca del Friuli and Lobster preserve the “G” witnesses. “G1” and “G2”, that are two 35 mm nitrates, tinted and toned, witness the 1918 French version, while “G3”, found spliced at the end of nitrate print of *Da Capodistria a Fiume italiana*, is a short fragment of the Italian version. During the 1990s, Cineteca del Friuli and Lobster Film duplicated and restored the film materials from 1918 at the Haghe Film Lab in Amsterdam. Presently, the restored 35mm copies from the nitrate prints are preserved by Cineteca del Friuli that holds the preservation master on acetate and the restored print on polyester.

Witness “RM” is a black and white duplicate negative (1000 m ca.) in four reels with flash intertitles on 35mm safety stock preserved by Istituto Luce. “RM” is a late and fourth generation dupe, probably coming from a nitrate print that retain large portion of the Italian and French 1918 versions, including some of the missing scenes in K and G.

Witness “MI” is a 35mm positive fragment on nitrate film preserved by Cineteca Italiana in Milan and close to the 1927 edition. The two reels were recently duped by L’Immagine Ritrovata and they witness the 1927 LUCE version, as attested by the intertitles and the insertion of later documentary materials.

An important aspect we must consider about film materials is that we are working with different materials (positives, negatives, duplicates) and we have to consider that the dpx sequences are coming from different film scanners, labs and, even before, from different photochemical routes and laboratories. In a certain sense, the critical digital edition will give an account and will allow to evaluate this material and formal polyphony, which would otherwise only be partially intuitable through a canonical viewing of the restored version.

Primary Sources

Alongside the *recensio* there is an ongoing systematic research of film-related primary sources, such as photographic sources coming from institutional and private archives (Archivio Centrale di Stato); documents from Italian censorship, military archives (USSME – Ufficio Storico Stato Maggiore dell’Esercito) and war museums (Museo Storico Italiano della Guerra – Rovereto, Istituto per la storia del Risorgimento italiano – Roma, Museo del Risorgimento e della Resistenza – Vicenza, Museo della Battaglia – Vittorio Veneto, Museo storico della 3° Armata – Padova), books, journals (“Il Mattino Illustrato” and “Kinema”), official bulletin and so on. Indeed, the survey of non-film materials should not only be considered an ancillary or secondary work to support, validate and aid the restoration and reconstruction tasks because it is a core activity central to placing the film artefacts (both in conceptual and material terms) in an intermedial and cultural chain and network. In other words, they frame our research objects as contemporaneously archival, archaeological, and historical artefacts within an entangled approach to preservation and restoration.

To give an example, we can mention the n. 14 of “La Guerra”, published in October 1918 by Treves and devoted to the Battaglia dall’Astico al Piave, fought between 15 and 24 June 1918 (the “Second Battle of Piave River” or “Battle of the Solstice”). The monographic issue presents several photography coming from the “Photographic Unit” of the *Comando Supremo del Regio Esercito*. The special issue share with the film a similar visual identity – the cover page and the title blocks – and the same war zone settings, being at that time the photographic and the cinematographic units

gathered, sharing vehicles, equipment and shooting contexts and events from similar points of view (https://www.europeana.eu/it/item/9200196/BibliographicResource_3000005915659_source). The issue n. 14 shows how the visual and narrative identity of the Battle was vehiculated through an intermedial network.

A Descriptive and Morphological Approach to the Film Artefacts

Excavation is the initial act of a process that sees no solution of continuity between discovery and recovery (Carandini, 2010). Therefore, a descriptive and morphological approach to the material artefacts is particularly important for our work. The descriptive-analytical study of the physical characteristics of films has a long history, which partly derives from the pioneering application of the so-called evidential paradigm by the “excavator” Harold Brown (Brown and Bolt-Wellens, 2020). We can sum up this long history through three different disciplinary areas: the well-known historical evidential paradigm framed by Ginzburg (Ginzburg, 1979); the descriptive approach derived from the philology of printed texts, mainly focuses on the analytical description of a book’s physical characteristics and modes of production (Tanselle, 2020); and the forensic approach, meant as one of the recent efforts by digital media studies to frame the relationship between formal and material artefacts (Kirschenbaum, 2008).

Focusing the attention into the descriptive level, means that to be able to operate concretely, historians dealing with archival materials must have developed a clinical eye, since in practice excavation unfolds through direct and instrumental diagnostic investigation of the artefact.

Here, we propose to divide this descriptive and morphological approach in a *non-isomorphic* and an *isomorphic* description. In this perspective, the application of the philological method, specifically the *recensio* and *examinatio* addressed to frame critically the film tradition, means dissect and examine the film as an organic and formal structure.

We are using the non-isomorphic description to describe, annotate and report several information about formal and material characteristics of the artefact, such as the shots, intertitles transcriptions, edge codes, color annotations, references to the proxies and/or visual recordings produced through repro-set documentation devices; that means the artefact description through the *découpage* and the annotations.

In a genealogical and archaeological perspective, the non-isomorphic description is based on old, layered tools such as so-called *découpage*. On one hand, *découpage* is a prismatic theoretical concept, developed inside the classical theory of Film in Europe. In this meaning, *découpage* is conceived as an entomological and anatomical approach to the formal and material artefact, in order to dissect it.

For the isomorphic description, or the artefact visualization, our case study can count on three different ways to document the film artefacts: screeners, edge-to-edge scanning and “repro-set” shootings. Screeners are what it is usually called proxy files: in computer science, a intermediary machine; in digital post-production, they are duplicates of a project’s source footage, transcoded files smaller in size and at a lower bitrate than the original. They also recall an idea of proximity, wherein the idea of “nearness” does not so much recall what is near in terms of closeness to the origins but instead close to us: the “latest, the most recent; the next, the following”. Edge-to-edge visualizations, practiced in Udine since the early 2000s, could be framed as a mode of visualization grounded on the philological tradition, an equivalent of the so called “mechanical” or “photographic” edition of a manuscript or a book. They allow archivists, restorers, and scholars to observe and analyze several information, such as the edge codes or the handwritten numbers of the scenes, and they are particularly useful for those copies we are not allowed to directly observe, now due to the pandemic, but we need to analyze for the reconstruction choices (Fig. 1). Thirdly, tools and operative methodologies such as those developed by “repro-set” devices could be seen as a first and consolidated example of a diagnostic approach, originated from those used in the traditional cultural heritage fields, that will help us with the textual and visual reconstruction following the identification of the practices that have led to the current morphology of the witness, such as studying the different tinting and toning, the edge codes, the different layers, and the splices shapes, etc. (Fig. 1).

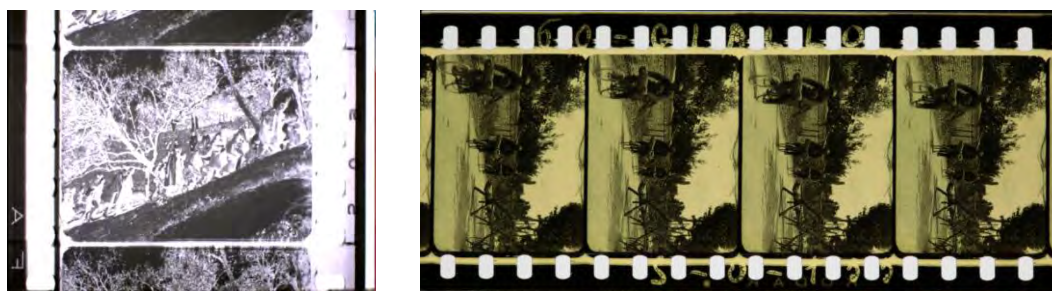


Fig. 1. On the left, an example of an edge to edge scanning, specifically made by Istituto Luce for the project (Witness RM – Reel 1- frame 3093): it allows to understand and document the provenance of the dupe neg and the main characteristics of the previous. On the right, an example of a “repro-set” documentation with the handwritten indication for editing and tinting for the positive prints “60- GIALLO” and the identification code of the film “S – O – 155”. It is also possible to see the edge code KODAK ■ that allows to date the film stock to 1917.

Studying the physical characteristics of the film also means identifying and classifying specific manifestations that altered its material texture. We have accurately analyzed each witness, that retain a specific own material and cultural history, and we have created an intervention list, a set of rules of engagement for the digital restorer, considering still valid and very useful the subdivision of the alterations into *damages*, *errors*, and *defects*. While damages (biological, chemical, mechanical) are due to the use or the negligence and the decay of materials, errors are the alterations occurred during the content transmission or the duplication process of the materials (Brandi, 2000). Both damages and errors can be amended because they are part of the further history of the film artefact. Instead, defects own to the domain of the original, they describe how the technical limits and/or specific non-normative practices can shape the film since its very first occurrence, and so, we must preserve them.

Collatio and Loci Critici

To achieve the *restitutio textus*, beside the *recensio* and the *descriptio* a huge amount of *collatio* work is required to compare witnesses, recognize variants and errors, and frame the so-called *loci critici* (Fig. 2).

5	Soldato carica un cannone e spara (x2)	K8	23065	23105	41	G1	89108	89222	115	RM1	1752	1888	117
5*	Sparo di un cannone più ravvicinato	K3	22106	22184	79	G1	89223	89299	77	RM1	1869	1942	76
07	Valletta e Costalunga.	K2	52	131	80	G1	89300	89414	115	RM1	1943	1947	5
5**	V. BLEU - I. ROSS (panoramica aerea)	K2	132	575	444	G1				RM1	1948	2391	444
08	La Cima Valletta.	K2	576	654	79	G1	89863	89961	99	RM1	2392	2396	5
6	I ROSA (soldati nelle trincee in montagna e in movimento)	K2	655	1081	427	G1				RM1	2397	2865	465
09	Proiezioni aeree: catturati a Cima Valletta e a Col dei Revo.	K2	1082	1229	148					RM1	2862	2866	5
[7]		K2	1230	2947	1718					RM1	2867	4895	1829
010	I nostri cannoni battono la zona invasa del Mostro.	K2	2948	3009	122	G1	90439	90607	169	RM1	4696	4700	5
8	GIALLO (soldati caricano il cannone e cannoni che spara)	K2	3070	3721	652	G1	90606	91272	667	RM1	4701	5335	655
8*	GIALLO (soldati caricano il cannone e sparano tra gli alberi)	K2	3722	4081	360	G1	91273	91641	371	RM1	5356	5722	367
9	GIALLO (Prati con casa e spari in lontananza)	K2	4082	4459	338	G1	91644	91995	352	RM1	5723	6066	344
10	GIALLO (Carica e spara di cannone tra gli alberi)	K2	4460	4725	306	G1	91996	92318	324	RM1	6067	6389	323
11	GIALLO (Prati con casa e spari in lontananza)	K2	4726	4822	97	G1	92319	92471	153	RM1	6390	6542	153
12	GIALLO (cannone tra le montagne)	K2	4823	4944	122	G1	92472	92591	122	RM1	6543	6661	119
13	GIALLO (caricamento cannone e spara da dietro al cannone)	K2	4945	5590	646	G1	92594	93148	655	RM1	6662	7307	646
14	GIALLO (Prati con casa e spari in lontananza)	K2	5591	5850	260	G1	93149	93518	370	RM1	7308	7578	271
15	GIALLO (Caricamento cannone e spara da laterale al cannone)	K3	14067	14432	366	G1	93519	93899	381	RM1	7579	7956	378
011	Mostrare il nemico tra i gas asfissianti.	K3	14433	14488	56	G1	93900	94092	193	RM1	7957	7961	5
17	GIALLO (Soldati caricano il cannone e spara da lato frontale)	K3	14489	14574	86	G1	94093	94188	96	RM1	7962	8041	80
16	GIALLO (Prati con casa e spari in lontananza)	K3	14575	14703	129	G1	94189	94318	132	RM1	8042	8189	128
17*	GIALLO (Soldati caricano il cannone e spara da lato frontale)	K3	14704	15149	446	G1	94319	94766	448	RM1	8170	8624	455
18	GIALLO (Prati con casa e spari in lontananza)	K3	15150	15290	141	G1	94767	94908	142	RM1	8625	8758	134
19	GIALLO (Soldati caricano il cannone e spara tra le trincee)	K3	15291	15573	281	G1	94909	95210	311	RM1	8759	9055	257

Fig. 2. *Collatio* of the film materials through comparative chart (left); and through visual comparison (right)

To support it, a comprehensive and meticulous study of the material and production techniques (tinting, toning, splicing, organization of the cinematographic unit and of the laboratory involved, etc.) is necessary to establish and reconstruct the text. For example, we can mention the reconstruction of missing intertitles not preserved by the base-text, the witness “K”. We have looked for all the sources available from the period (censorship approval, intertitles lists and so on) but we are still missing the first six Italian intertitles. We have found in the French 1918 version thanks to the same intertitle number in the corner, but they have an order that does not follow the intertitle progressive numbers and they do not fit with the Italian 1927 version (Fig. 3). Their reconstruction involves many questions about how to deal with them since we do not have documentation about this choice. Verified that also the survived prints followed strictly the same production process adopted for the 1918 Italian version, we could only suppose it is due to the different importance of the Italian Monarchy in France that made more important the film essential information, while in Italy the presence of the portrait of the Kingdom or a direct appeal to the audience present at the screening forced necessarily the audiences to stand up and pay tribute.



Fig. 3. The first four intertitles from the French 1918 version follow an unruly order but they are the only existing proof of those intertitles. The number in the bottom-right corner identifies the film (R37, the same number for the Italian) and the version (F, for French) while in the bottom-left corner there is the intertitle number: 3-2-4-1.

In other cases, we have a correspondence with the scenes in witness RM and that would give us ten missing intertitles and related sequences for the reconstruction, but they belong both to the 1918 version and to the 1927 Luce-re-edited version, with a sort of uncertainty about how to frame them. Here the evidential paradigm must dialogue with the interpretive one, giving space to formal and narrative study and evaluation of lessons more likely to be true than others. Then, we must discuss if it is proper to report them or not in the version we are reconstructing and how to visualize the intertitles. When they come from the French Version (witnesses “G”) or from witness “RM” we have decided not to simulate the Italian 1918 edition title block, but to put the intertitle text in square brackets and likewise the attributed intertitle number (e.g. [Col Moschin] – [5] – [R37])

Historical-Critical Digital Environment

Since the surveys and the research are finding out many and many different practices that shaped the multiple originals, many relationships among those sources and contaminations between the copies we have decided to build up a web-based historical-critical digital environment for films and to document the film restoration process. In this environment, it will be possible to see the restored film as in a classical viewer, but, according to the interest of the audience, it also will allow to watch the original materials, analyze the variants, see the analogy or differences among them, and going through the *loci critici*; it will allow to see the restoration interventions and make before and after comparisons. It will be possible also to see both the edge-to-edge proxy and the “repro-set” documentation. We will also make accessible all the non-filmic sources we are working with.

Conclusion

In conclusion, despite having chosen the 1918 Italian version, our aim is not strictly focused on the canonical reconstruction and restoration of a single chosen version. Rather we aim to give an account of the restoration process instead of the final product; the practices that shaped the multiple originals, the relationship between the different sources, the different genealogies, as well as the accidents, contaminations and finally the archival status and provenance of the film materials.

Bibliography

- Barnard, T., Kessler, F. and Le Forestier, L. (2020) *Montage, Découpage, Mise En Scène: Essays on Film Form*. caboose.
- Bleeker, E., Buitendijk, B. and Haentjens Dekker, R. (2019) ‘From Graveyard to Graph. Visualisation of Textual Collation in a Digital Paradigm’, *International Journal of Digital Humanities*, 1.
- Brandi, C. and Basile, G. (2005) *Theory of restoration*. Roma: Firenze: Istituto centrale per il restauro; Nardini (Arte e restauro).
- Brown, H. and Bolt-Wellens, C. (2020) *Physical characteristics of early films as aids to identification*. Bruxelles: Fédération internationale des archives du film.

Brunetta, G. P. (1985) 'La Guerra Lontana. La prima guerra mondiale e il cinema tra i tabù del presente e la creazione del passato', in Zaffoni, B. (ed.). *La Grande Guerra. Esperienza, memoria, immagini*, Rovereto.

Cadorna, L. (1921) *La guerra alla fronte italiana fino all'arresto sulla linea della Piave e del Grappa (24 maggio 1915 – 9 novembre 1917)*. Treves.

Canosa, M. (2001) 'Per una teoria del restauro cinematografico', in Brunetta, G. P., *Storia del cinema mondiale. Teorie, strumenti, memorie*. Torino: Einaudi.

Carandini, A. (2010) *Storie della terra: manuale di scavo archeologico*. Torino: Einaudi.

Dupont, A. (1928) *La battaglia del Piave*. Roma: Tipografia del Littorio.

Fabi, L., Penco, G., Šuc, Ž., Moser, C., Jurc, V., Panizon, N., Petrovec, J., Malalan, D., Cimprič, M. and Cimprič, Ž. (2006) *Dvojni pogled na prvo svetovno vojno 'filmi resničnosti' od 1915 do 1918 med kinematografijo, vojno in propagando = Doppio sguardo sulla Grande Guerra: i 'dal vero' del 1915-18 tra cinema, guerra e propaganda*. Gemona: La Cineteca del Friuli.

Faccioli, A. (ed.) (2016) 'Immagini in trincea. La lunga vita dei filmati e delle stereoscopie della Grande guerra', *Immagine. Note di Storia del Cinema*, 13.

Faccioli, A. (2020) *Visioni della Grande guerra Immagini sopravvissute, ritrovate, riutilizzate*. Kaplan.

Faccioli, A. and Parigi, S. (eds) (2020) 'Apocalissi italiane. Il cinema e la televisione di fronte ai disastri del Novecento', *Immagine. Note di Storia del Cinema*, 21.

Ginzburg, C. (1979) 'Clues: Roots of a scientific paradigm', *Theory and Society*, 7(3).

Guida ai campi di battaglia (1919). Agenzia italiana pneumatici Michelin editrice.

Kirschenbaum, M. G. (2008) *Mechanisms: new media and the forensic imagination*. Cambridge, Mass: MIT Press.

La Guerra: dalle raccolte del Reparto fotografico del Comando supremo del R. Esercito (1918). Milano: Treves, 1916-1921 (14).

Laura, E. G. (1999) *Le stagioni dell'Aquila. Storia dell'Istituto LUCE*, Ente dello Spettacolo, Rome.

May, R. (1939) 'Storia e tecnica della sceneggiatura', *Bianco e Nero*, (12).

Mola, A. A. and Zarcone, A. (eds) (2014) *Dall'Isonzo al Piave: 24 ottobre-9 novembre 1917; relazione della commissione d'inchiesta, R. decreto 12 gennaio 1918 n. 35. 2: Le cause e le responsabilità degli avvenimenti*. 1. rist. [de l'ed.] Roma 1919, 2. ed. Roma: Rodorigo.

Olsen, B., Shanks, M., Webmoor, T. and Witmore, C. (2013) 'Archaeology: The Discipline of Things', *Archaeological Journal*, 170(1).

Pesenti Campagnoni, S. (2013) *WWI La guerra sepolta. I film girati al fronte tra documentazione, attualità e spettacolo*. Facoltà di Lettere e Filosofia. Università degli Studi di Torino.

Pregolato, M. (ed.) (2014) *Dalle rovine della grande guerra. Le nuove chiese sul lungo Piave. Fonti e spunti critici per la valorizzazione*.

Colour Photography and Film:

Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials

Price, K. M. and Siemens, R. (eds) (2013) 'Welcome', in *Literary Studies in the Digital Age*. Modern Language Association of America.

Tanselle, G. T. (2020) *Descriptive bibliography*. Charlottesville: The Bibliographical Society of the University of Virginia.

Zadra, C. (2020) 'Il fondo fotografico Maurizio Rava', in *Annali. Museo storico italiano della Guerra*. (28)

The Flexichrome: visual examination and scientific analysis of an overlooked color photographic process

Nayla Maaruf¹, Sylvie Pénichon¹, Maria Kokkori¹

¹ The Art Institute of Chicago, Conservation and Science

Contacts: Naayla Maaruf, nmaaru@artic.edu; Sylvie Penichon spenichon@artic.edu;
Maria Kokkori, mkokkori@artic.edu

Keywords: Color Photography, Photographic identification, Material-technical analysis, Flexichrome Process

Extended Abstract

The recent display at the Art Institute of Chicago of a color photograph by California photographer Herbert Lyman Emerson (1908–1983) prompted in-depth research into its photographic process. Prior to its acquisition, the print had been identified as a hand-colored gelatin silver print. Due to the vibrancy of colors and overall appearance, however, it was suspected that it could instead be a Carbro print—a pigment process where three pigmented gelatin relief layers are combined to form a full color image—overpainted for commercial printing purposes. A more detailed visual examination did not reveal evidence of the superimposed yellow, magenta and cyan-colored layers characteristic of the Carbro. Non-invasive portable XRF analysis confirmed the absence of silver but also revealed the absence of chromium, an element detectable in Carbro reference prints. The close visual examination and analysis lead to the conclusion this print is a Flexichrome, a dye imbibition process with visual characteristics similar to those of the carbro where a gelatin relief is hand-painted with acid dyes to form a full color image. This finding led to further historical and material research into this elusive photographic process.



Fig. 1 - (Left) Herbert Lyman Emerson (American, 1908–1983), *Untitled (for a Propaganda Poster)*, 1950s, Flexichrome, 37.1 × 49.2 cm (image); 37.9 × 50.2 cm (paper), The Art Institute of Chicago, 2012.282, Gift of Robert A. Taub. (Right) Portable XRF analysis on 2012.282.

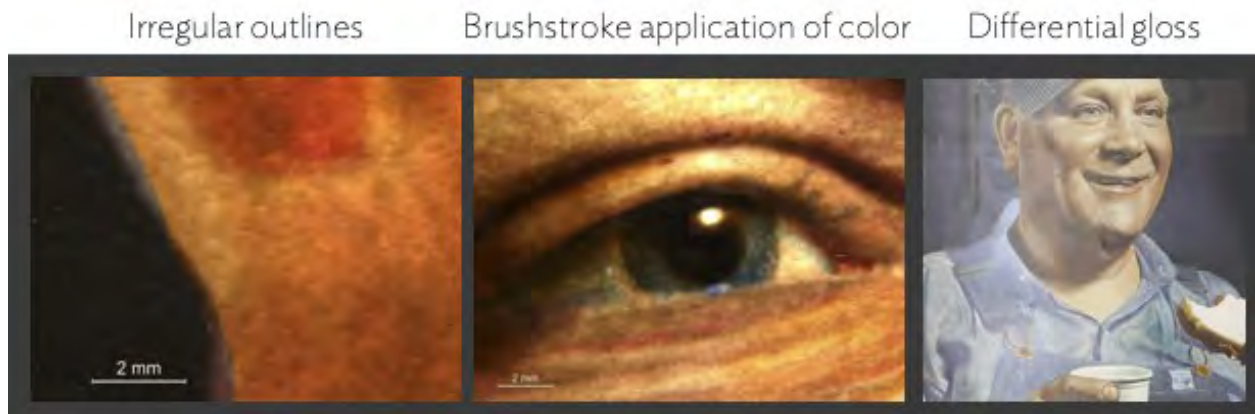


Fig. 2 - 2012.282 close up of visual examination (left) irregular outlines caused by manual color application, (middle) visual brushstrokes in delicate areas imbibed in the image layer, (right) differential gloss.

The Crawford Flexichrome was first developed and marketed by Jack Crawford in 1940. Kodak purchased the patent from Crawford and remarketed it as the Kodak Flexichrome from 1949 until 1961, when it discontinued its production. This research will present a historical and technical overview of the Flexichrome process and will investigate the materials and possible variations in the product formulations through the study of the Art Institute's photograph alongside selected Flexichrome reference prints and historic Kodak Flexichrome dye sets. Prints and dye samples were characterized using a complement of analytical techniques including visible and fluorescence light microscopy (VLM, FLM), x-ray fluorescence (XRF) spectroscopy, and Fourier transform infrared (FTIR) spectroscopy. A key goal of the study is to establish visual and analytical identification markers for Flexichrome prints and transparencies, and to provide preservation guidelines to conservators and collection managers.



Fig. 3 - (Left) Crawford Flexichrome outfit advertised in: Crawford, J. (1942). *The Flexichrome Process. The Complete Photographer*, 5(28). (Right) Kodak Flexichrome Advertisement.

Non-destructive Analysis of Hand-Colored photographs: A Case study on photographs dating back to the 19th century

Emil Henin¹

¹ Head of Coptic painting conservation Department, Ministry of Tourism and Antiquities, Egypt

Master of Science (M.Sc.) in Conservation of Antique Photographs and Paper Heritage:

Thesis title: "Chromatic Changes in Hand-coloured Photographic Prints: An Experimental Study on a Selected Collection ", Helwan University- Cairo and Catania University– Italy.

Contact: Emil Henin, omel2010@yahoo.com

Abstract

Hand-coloured photographs are very sensitive to their environmental condition; accordingly, they must be preserved in appropriate conditions to ensure their long-term preservation. This research presents a scientific study on hand-coloured photographs in terms of their history, their technical evolution and the chemical composition of the pigments used. Various analytical techniques will be employed to determine the chemical composition of the materials.

In particular, the main aim of this study is the characterization of the samples to identify chemical composition of the pigments and dyes in Hand-Colored photographs with X-ray fluorescence. These techniques are useful for the evaluation of the optical and chromatic characteristic of the samples and for the individuation of chemical elements, respectively.

X-ray fluorescence spectroscopy (XRF) is commonly used in the field of heritage science and conservation for the in situ and non-destructive elemental analysis of a broad range of art and archaeological artifacts. In studies of fine art photography, both modern and historical, XRF is used primarily to identify the photographic processing chemistry and the nuances associated with chemical composition of the image layer.

Keywords: Hand Coloured photographs, X-ray fluorescence, pigment, baryta layer, Over-painted

Introduction

Photographs were coloured in one of two ways: hand tinting or hand colouring refers to a lightly painted image that is still distinguishable as a photograph; over-painting refers to an image that has been heavily painted and whose photographic origins may have been completely obscured (Rinhart, 1981; Hendricks, 1991; Henisch, 1996). Over-painted images mainly served as modern portraiture or as a way for an artist to pawn off an image as a freehand work of art, and often involved altering undesirable aspects of the original photograph. The cost of a painted photograph depended greatly on the amount of paint applied to the print (Burns, 1995). Before the introduction of the tintype, any photographic portrait was too costly for most people, but the tintype was a much cheaper alternative and brought photographic portraiture to the masses. Having a hand-coloured photographic portrait became a status symbol, though most lower class people could only afford a rosy tint on the cheeks and gold paint on jewellery (Burns, 1995; Henisch, 1996).

Any photograph could be coloured in a variety of ways, but most colourists preferred to work with photographs that were not overdeveloped and contained the entire range of tonal values (Henisch, 1996). Since the silver layer absorbed colour differently than the rest of the photograph, the colourist would often use a coating of varnish to create an even appearance. Colouring was seen as something that should enhance the photograph and not obscure it (except in the case of over-painting), so it was recommended to apply a few light layers of colour until the right shade was achieved rather than one dark coating (Towler, 1969; Henish, 1996). Most colourants needed the

addition of a binding material such as gum Arabic to adhere to the photographic substrate. The colours most often used for colouring photographs were India red and pink madder for colouring cheeks, and gold paint for colouring jewellery (Rinhart, 1981).

The main aim of the present study is the identification of pigments by X-ray fluorescence: A Case study on photographs dating back to the 19th century (Figure 1 Woman_01 , Figure 2 Paris_04)



Fig. 1 – Woman_01



Fig. 2 – Paris_04

X Ray Fluorescence (XRF) analysis

X-ray fluorescence spectroscopy (XRF) is commonly used in the field of heritage science and conservation for the in situ and non-destructive elemental analysis of a broad range of art and archaeological artifacts. In studies of fine art photography, both modern and historical, XRF is used primarily to identify the photographic processing chemistry and the nuances associated with chemical composition of the image layer. The utilization of X-ray fluorescence technique for the determination of trace element concentrations in the four selected photographic sample groups and the pigments used for hand-colouring the photographs is presented. The XRF analyses have been performed utilizing the fluorescent X spectrometer, Lithos 3000 (ASSING). It is one of the smallest existing analysis systems, and it is ideally suited for in situ analysis and requires no sample preparation.

The X-ray source is constituted by a conventional tube, air forced cooling type, operating at a voltage of 30KV maximum acceleration and a maximum current of 0.5 mA. The detection system, whose resolution is of about 160 eV, is constituted by detector energy dispersive. The pointing system is constituted by a laser interferometer, which measures the distance between the instrument and the sample. This system allows the positioning of the fire point with a $\pm 15 \mu\text{m}$ error. For each sample, the parameters used for the analysis is: 20kV and 100 seconds of acquisitions. The

information about the sample comes not only from the surface but also from the underlying layers, according to a penetration depth that depends strictly on the elemental composition of the surface and can therefore vary from point to point. Heavy elements (Au, Hg, Pb) will tend to limit the penetration, while light elements (Na, K, Mg, Ca) will be less shielding.

Results and discussion

By analyzing the two selected prints (i.e. Woman_01 and Paris_04, both belonging to the old group) with X-ray fluorescence spectroscopy, it is possible to see the differences between their chemical compositions.

Figure 3 represents a spectrum of sample Woman_01. Results reveal the presence of barium and of the calcium. Both elements were found in most analyzed samples. Both are related to the composition of the paper. Barite is a special barium sulphate coating, known as the baryta layer that is traditionally applied to a fiber-base photographic paper prior to coating with the emulsion layers. The technical benefits of the baryta layer include greater detail and definition, extended tonal range and excellent archival properties. In addition, fiber-base photographic papers coated with a baryta layer have a unique look and feel which has become the standard for fine art photographers worldwide. Baryta-coated photographic papers have been developed since of the nineteenth century. Over the years the use of this compound has declined in favor of resin coated photo papers.

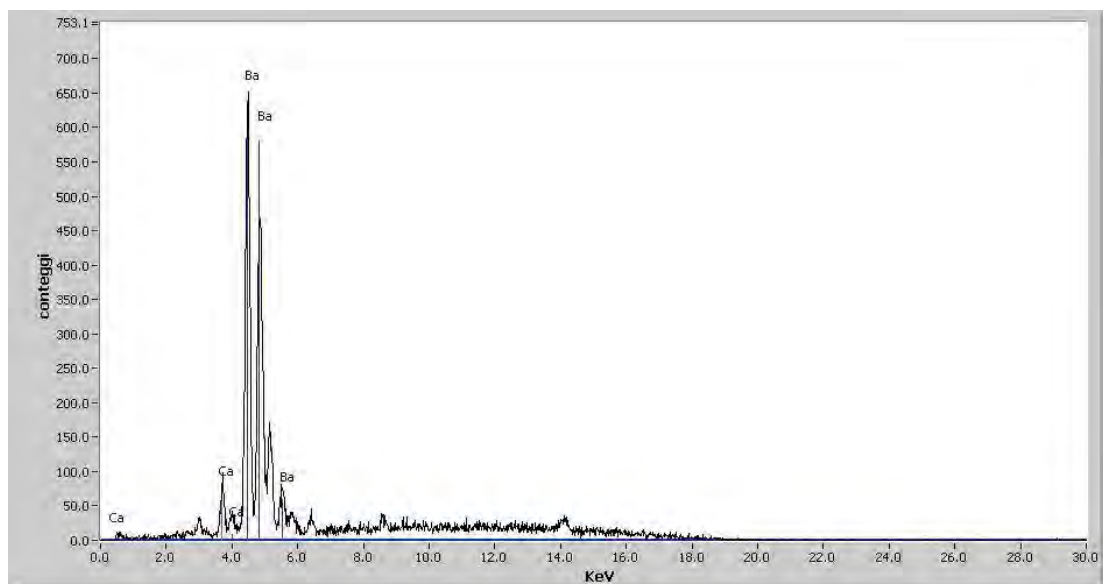


Fig. 3 – XRF spectrum of a sample of old group

Figure 4 represents the spectrum for the red pigment used in sample Paris_04. The absence of barium indicates that the photographic paper does not include a baryta layer within its structure. The results revealed the presence of mercury (Hg), which is related to the cinnabar pigment. The red pigment cinnabar (HgS) has been used as a painting material for thousands of years in many cultures (Nöller, 2014).

By analyzing another red pigment found in sample Woman_01 Figure 5, the resulting spectrum revealed the presence of both barium and calcium. Arsenic (As) was also found in the sample indicating that the red pigment used is most likely realgar (As₄S₄), a red–orange used by artists from different cultures since antiquity (Keune et al., 2016).

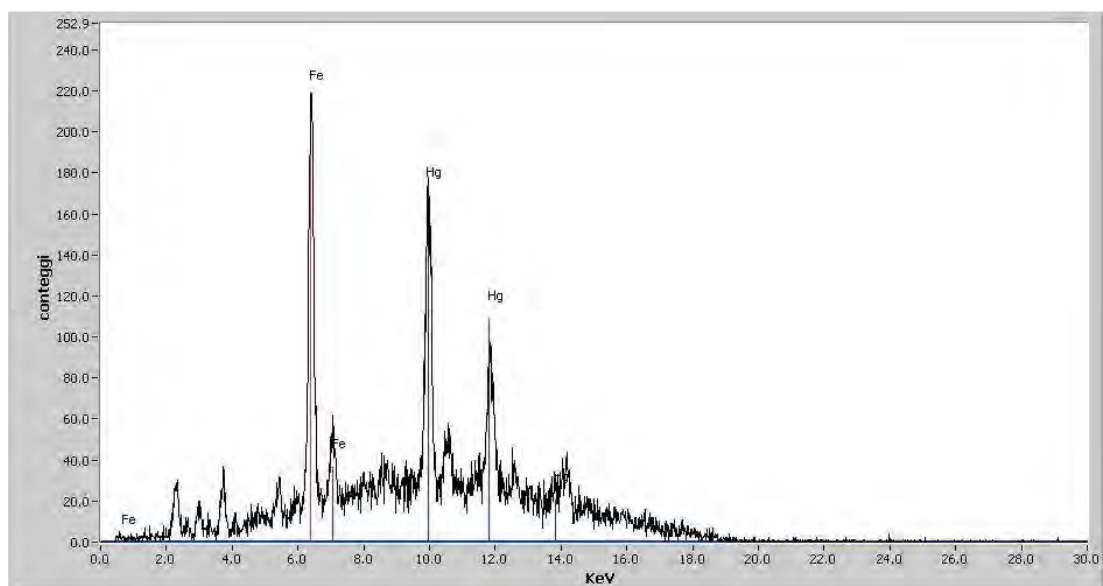


Fig. 4 – XRF spectrum of red pigment of Paris_04_r2 (Old Group)

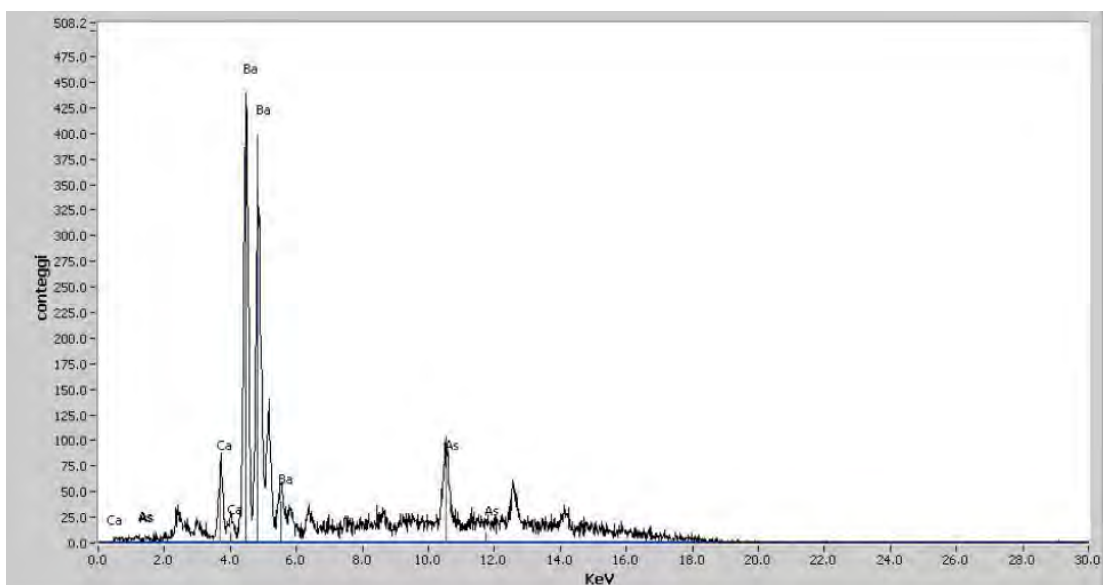


Fig. 5 – XRF spectrum of red pigment of Woman_01_r3 (Old Group)

The obtained results for the blue pigment used in sample Woman_01 as shown in Figure 6 reveals the presence the presence of cobalt indicating that cobalt blue was used. Cobalt blue is an inorganic oxide of cobalt and aluminum. Cobalt blue dark and cobalt blue light ($\text{CoO} \cdot \text{Al}_2\text{O}_3$) pigments were already used in ancient Egypt for decorating pottery. Cobalt blue greenish ($\text{Cr}_2\text{O}_3 \cdot \text{CoO} \cdot \text{Al}_2\text{O}_3$) was produced in the middle of the 19th century. The colour of pigment varies from bluish green to greenish blue depending on the molar ratio of aluminum and chromium (Jonynaitė et al., 2009).

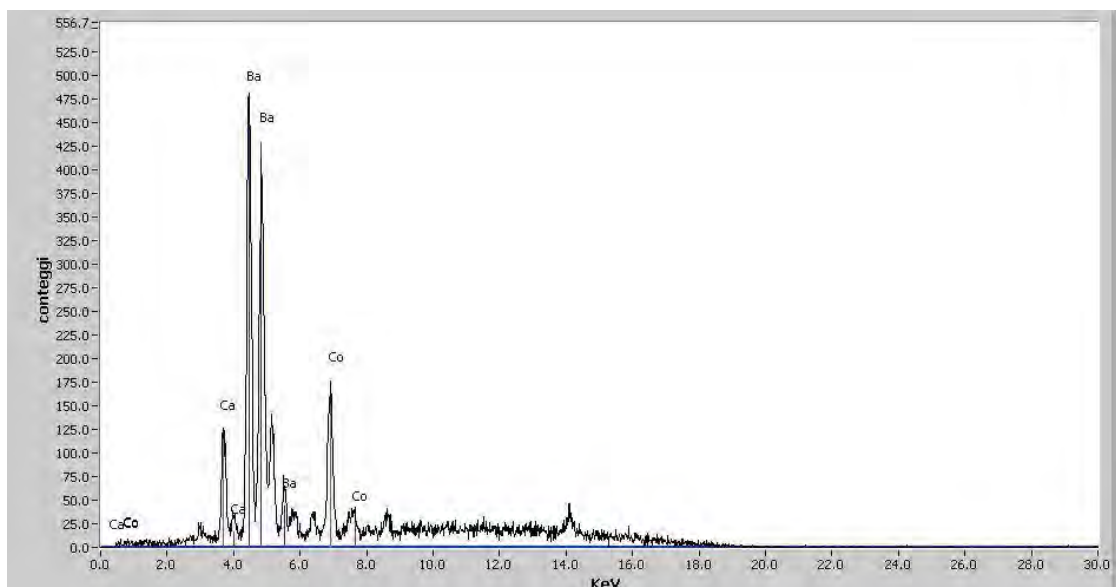


Fig. 6 – XRF spectrum of blue pigment of Woman_01-b2(Old Group)

The identified yellow pigment in sample Paris_04 is most likely yellow ochre, this result was suggested due to the presence of iron (Fe) as shown in Figure 7 . (Mastrotheodoros et al., 2010).

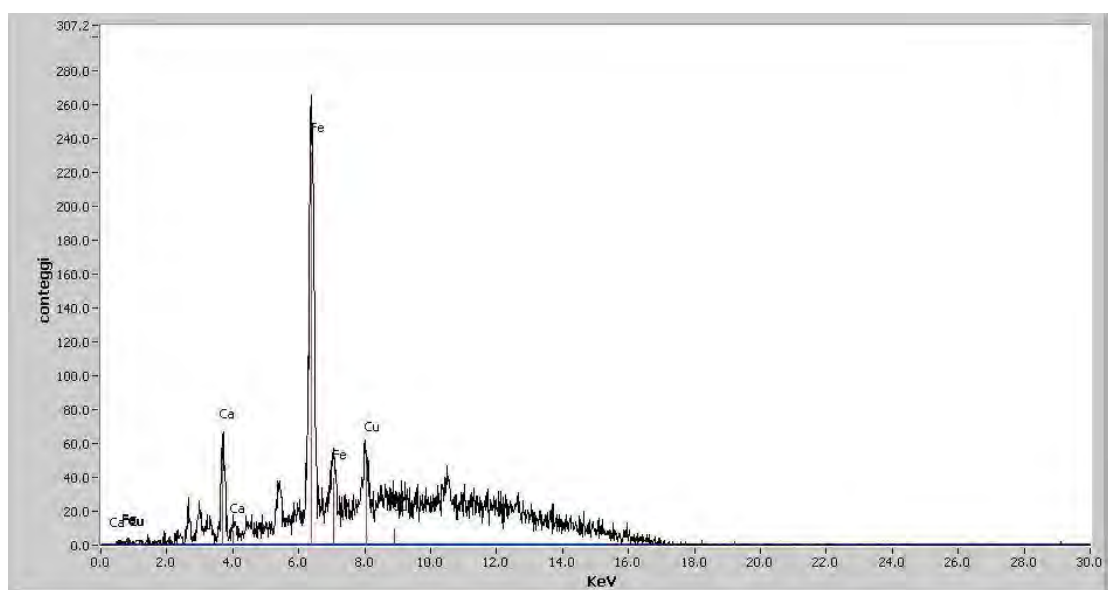


Fig. 7 – XRF spectrum of yellow pigment of Paris_04_y1(Old Group)

Conclusion

XRF analysis was used primarily to identify the photographic processing chemistry and the nuances associated with chemicals. It was also possible to identify others elements useful for the identification of the pigments (cinnabar, realgar, cobalt, yellow ochre); however, many samples analyzed contains barium and calcium in the composition related to the preparation of the images.

Bibliography

Burns, S. *Forgotten Marriage: The Painted Tintype & the Decorative Frame, 1860-1910: A Lost Chapter in American Portraiture*. New York: Burns Press, 1995.

Hendricks, K.. *Fundamentals Of Photograph Conservation: A Study Guide*. Toronto: Lugus Publications, 1991.

Henisch, H. & Henisch, B.A.. *The Painted Photograph 1839-1914 Origins, Techniques, Aspirations*. University Park, PA: The Pennsylvania University Press, 1996.

Jonynaitė D. , Senvaitienė J. , Kiuberis J. , Kareiva a. , Juškėnas R. , R 18 Imantas Ramanauskas, XRD Characterization Of Cobalt - Based Historical Pigments And Glazes, *Chemija*. Vol. 20, No. 1., 2009.

Keune, K., Mass, J. , Mehta, A. Church, J. and Meirer, F. *Analytical Imaging Studies Of The Migration Of Degraded Orpiment, Realgar, And Emerald Green Pigments In Historic Paintings And Related Conservation Issues*, 2016.

Mastrotheodoros, G., Beltsios, K., Zacharias, N., *Assessment Of The Production Of Antiquity Pigments Through Experimental Treatment Of Ochres And Other Iron Based Precursors*, *Mediterranean Archaeology and Archaeometry*, Vol. 10, No. 1, 2009.

Rinhart, F. & Rinhart, M., *The American Daguerreotype*. Athens: University of Georgia Press., 1981.

Towler, J.,. *The Silver Sunbeam: A Practical Text - Book On Sun Drawing And Photographic Printing: Comprehending All The Wet And Dry Processes At Present Known... (Facsim. Ed.)*. Hastings - On - Hudson, NY: Morgan And Morgan, Inc., 1969.

deep-doLCE – A Deep Learning Approach for the Color Reconstruction of Digitized Lenticular Film

Giorgio Trumpy¹, Stefano D’Aronco², Jan Dirk Wegner^{2,3}, Joakim Reuteler⁴

¹ Department of Film Studies – University of Zurich

² EcoVision Lab - Photogrammetry and Remote Sensing Group – ETH Zurich

³ Institute for Computational Science – University of Zurich

⁴ ScopeM – ETH Zurich

Contact: Giorgio Trumpy, giorgio@trumpy.eu

Abstract

Some of the first home movies in color were shot on 16 mm lenticular film during the 1920s to 1940s. This very special film is embossed with a vertical array of hundreds of tiny cylindrical lenses that allowed to record color scenes on a black&white silver emulsion. The most efficient approach to obtain digital color images from these historical motion pictures is to scan the silver emulsion in high-resolution and let a software extract the encoded color information. The present work focuses on the localization of the lenticular screen, which is the first and most complicated step of the color reconstruction. A ‘classic’ signal processing method proved to deliver successful results in some cases, but often adverse factors—damaged or warped film, scanning problems—hinder the successful localization of the lenticular screen. *Deep-doLCE* explores a more advanced and robust method, using a big dataset of digitized lenticular films to train a new deep learning software. The aim is to create an easy-to-use software that revives awareness of the lenticular color processes thus making these precious historical color movies available again to public and securing them for posterity.

Keywords: lenticular film, color reconstruction, deep learning, film digitization.

Introduction

Lenticular film had a short period of success during the early 1930s when it was sold to amateur filmmakers to easily create color movies (Gordon, 2013). The introduction of the chromogenic monopack from the mid-1930s (*Kodachrome* and *Agfacolor Neu* were the first products) cut the ambitions of lenticular film to become a standard for professional film productions, and this type of film started to disappear. Despite this brief history, a significant amount of movies shot on lenticular film are today conserved in private and public collections around the world.

The most popular lenticular film was introduced in 1928 by Eastman Kodak under the name *Kodacolor*¹. The film is embossed with a vertical array of hundreds of tiny cylindrical lenses (Fig. 1).

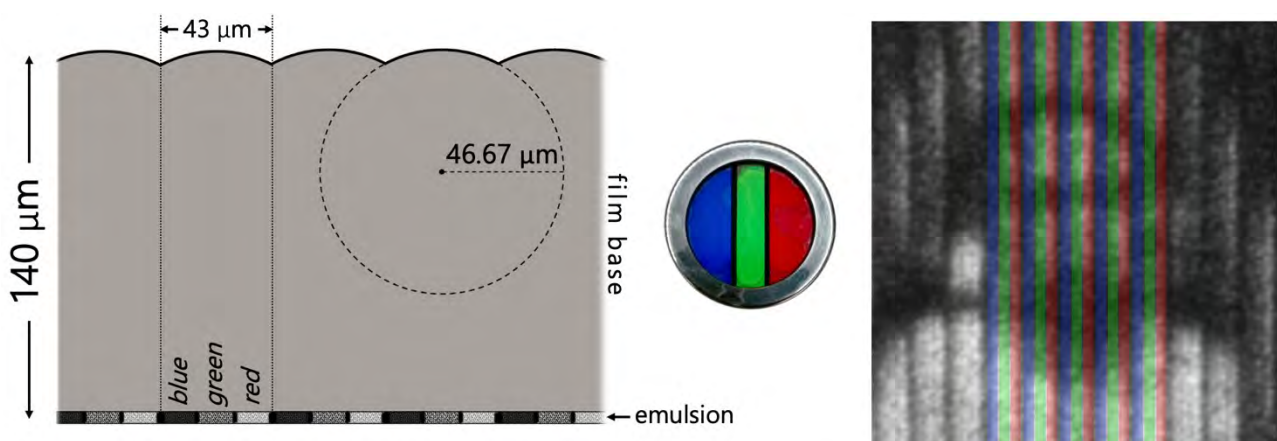


Fig. 1 - Spatial encoding of color in lenticular film. Left – Representation of the film’s cross-section with geometric information. Center – The filter used in front of the camera lens during shooting. Right – Image capture facing the emulsion side with superimposed color stripes.

¹ A brand-name that was later reused for completely different products.

In the image part of the 16 mm film (~10 mm) there are around 230 lenticules. The motion picture was captured with a tripartite red-green-blue filter in front of the camera lens (Fig. 1-center). The lenticules' focal length—three times their radius of curvature—correspond to the film thickness, and camera's focal length and aperture were devised to expose the photographic emulsion with separated color components (Capstaff, Miller and Wilder, 1937). After exposure, reversal processing created positive silver-based images with spatially encoded color information: the silver densities associated to the red, green and blue components lie side-by-side underneath each lenticule. The value of the color component is inversely correlated to the local amount of light-absorbing silver. The illustrative film section depicted in Fig. 1-left has an orange encoded color, since the silver density is high in the blue, medium in the green and, low in the red.

Digital color reconstruction

In the original procedure, the colors of lenticular film were displayed with a special projection device equipped with a filter equivalent to the one used during shooting. The projection was rather small and dim, and it could be only shown to few people in a small setting. Nowadays, the original filters for projection are hard to find and analog projectors are becoming obsolete. It is therefore difficult to display these films with the original procedure. Instead, the transformation of the image content into digital form enables a viable way to make these movies available to public, while at the same time preserving the image content that is otherwise subject to decay due to the aging of the film material. The most efficient approach to obtain digital color images from lenticular film is to scan the silver emulsion in high-resolution and let a software extract the encoded color information. In 2013 two independent works were presented in different fora (Reuteler, Fornaro and Gschwind, 2013), (Aschenbach, 2013), the first of which was conducted in the framework of the SNF project *doLCE* (University of Basel, 2012). The *doLCE* software reconstructs the color from high-resolution scans of lenticular film accomplishing two main tasks (Reuteler and Gschwind, 2014): the localization of the lenticular screen, and the conversion of the side-by-side silver densities into RGB values. In the example reported in Fig. 2, the lenticules' borders are highlighted with magenta stripes, and in each lenticule the blue component is on the left, the green in the center, and the red on the right.

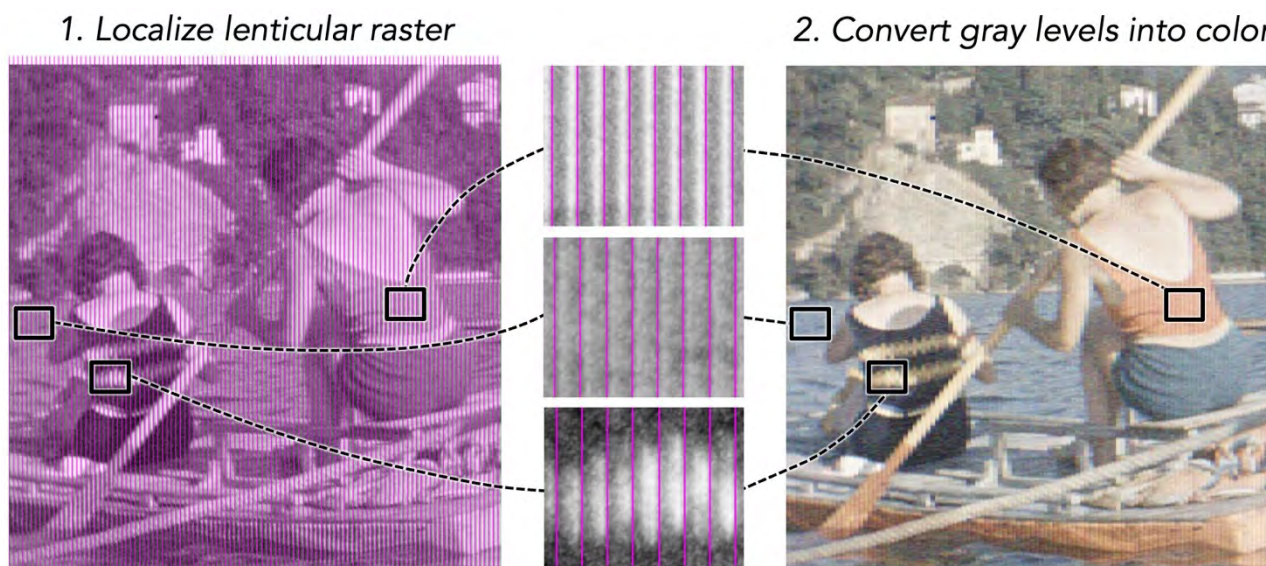


Fig. 2 - The two-step process for the digital reconstruction of the color information.

The lenticular screen is quite clearly discernible as a regular vertical pattern of dark stripes overlaying the photographic image. Its numerical localization with computers, however, can be complicated. The lines sometimes were not perfectly vertical and straight already from the film fabrication or got damaged and warped due to aging. Geometric distortions and defocusing might occur during scanning

due to film misplacement or optical aberrations of the imaging system. In addition, the silver particles constituting the photographic image obscure the lenticular pattern in all dense areas of the image. The doLCE software localizes the lenticular screen with a ‘classic’ signal processing approach, positively and efficiently reconstructing the colors in certain cases. However, when the above-mentioned complications are relevant, the proper localization of the lenticular screen is error-prone and often fails.

Instead of seeking to improve the success rate by introducing additional parameters to the existing software and making it more flexible, it was found convenient to adopt a completely different approach. The successful reconstructions carried out by doLCE were used to train a new computer algorithm, which is called *deep-doLCE*. The dataset of successful doLCE reconstructions was treated with techniques of data augmentation, so the training makes deep-doLCE able to handle the typical situations in which doLCE failed.

The dataset

In the framework of the SNF project *doLCE* (2012) at the University of Basel and the ERC Advanced Grant *FilmColors* (2015-2020) at the University of Zurich, a total of nine Kodacolor films were scanned for research purpose. The films constitute more than an hour of footage for a total of around 70’000 frames. They were scanned with three different scanners, with slightly different resolutions (ranging from 7’600 to 11’700 ppi, i.e. 13 to 20 pixels per lenticule), and stored with different types and levels of data compression (JPEG 2000, CineForm). This well-diversified collection of input images was processed with doLCE. For each frame, doLCE provides two outputs: a binary image that highlights the localized lenticular screen and the final color image (Fig. 3). An inaccurate localization of the lenticular screen is generally clearly visible in the final color image with unnatural fringes and other color artifacts. To create the training dataset, the whole set of resulting color images had to be visualized and judged to select the successful identifications of the lenticular screen.

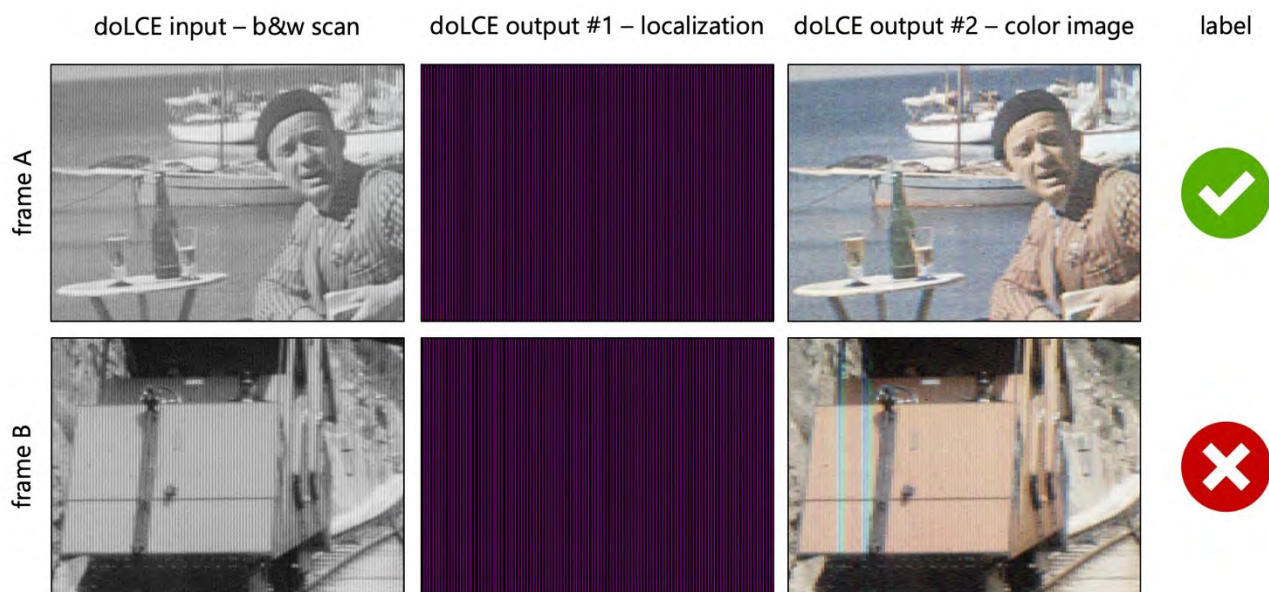


Fig. 3 - Color reconstruction with old-doLCE and selection of the successful reconstructions. Frame A (detail) shows pleasant colors, while Frame B (detail) exhibits two unnatural color fringes.

This onerous decision process was facilitated by a custom computer routine that presents the final color image and allows an operator to quickly label the localization as ‘accepted’ or ‘rejected’ with keyboard shortcuts (see example in Fig. 3). From the ~70’000 grayscale images, doLCE provided a training dataset consisting of two thousand unconditionally convincing color reconstructions, indicating that the localization of the lenticular screen was successful. The grayscale scanned film frames and the corresponding binary doLCE localizations were used to train a neural network.

The number of images was not big enough to avoid that overfitting degraded the performance of a deep-learning network. However, since the resolution of the images is three/four thousand pixels horizontally, the image pairs could be cut into one/two hundred patches of 256×256 pixels before being fed to the network. The outputs of the network were then recomposed into the complete image.

Data augmentation

The main limitation of the doLCE software is the strict requirement of perfectly vertical lenticules. Therefore, the dataset is exclusively composed by vertical lenticules, creating a critical bias in the training dataset that never exposes the neural network to tilted lenticules. Film scanning generally provides straight images, but minor deviations are likely to occur, especially with warped and damaged films. It was therefore necessary to perform data augmentation by randomly rotating by small angles the input and ground-truth images, so that the network learns how to deal with tilted lenticules. To avoid boundary effects and improve efficiency, the images from the doLCE dataset underwent a first cropping that extracts randomly positioned patches of 300×300 pixels, then a rotation with a random angle in the range from -1° to 1° , and finally a center cropping that extracts a 256×256 image to be fed to the neural network.

Network architecture and implementation details

In the recent years, deep learning (Goodfellow, 2016) has proven to be a powerful tool for solving a large variety of tasks. The main advantage of using data-driven machine learning approaches is that there is no need to develop an *ad hoc* model for the problem at hand, but existing generic models can be easily trained with the data available to solve the specific problem. Computer vision is one of the fields that benefited the most from such paradigm shift, and plenty of data-driven models for image object recognition, object detection, and image restoration have been developed.

The detection of the lenticule boundaries is a binary image segmentation process that determines for all the pixels of an input image whether they correspond to a lenticule boundary or not.

The *U-Net* is one of the most common network architectures for image segmentation. It has been introduced for fast and precise biomedical image segmentation (Ronneberger, Fischer and Brox, 2015), and has achieved promising results on a wide range of segmentation tasks. The presence of skip connections (see Fig. 4) allows the U-Net to perform effective segmentations, forwarding high-resolution features detected in the input images and obtaining sharp segmentation predictions.

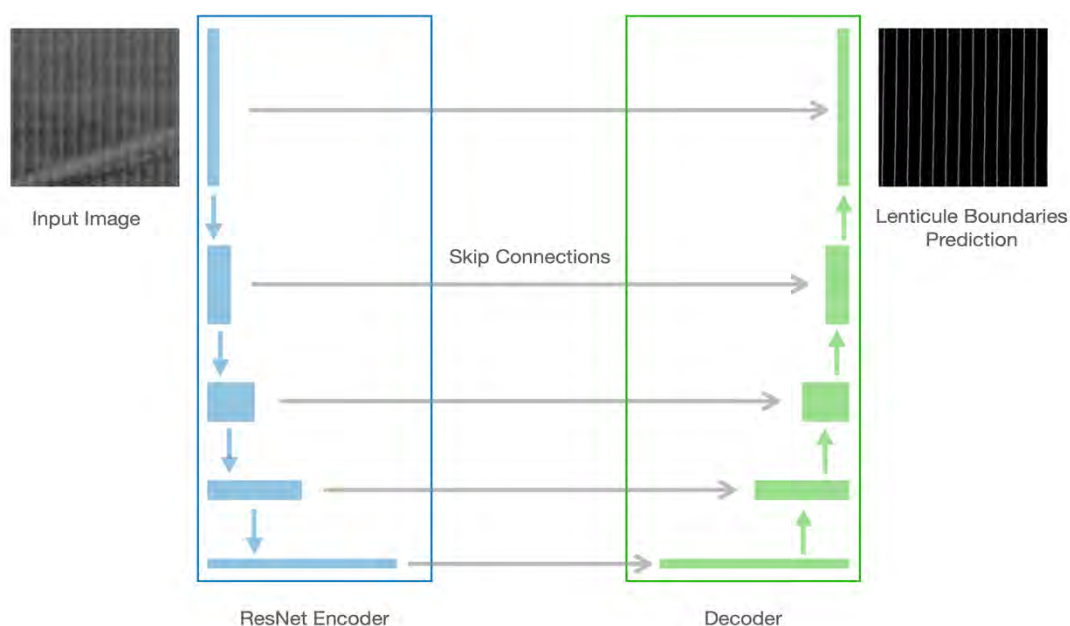


Fig. 4 – Simplified diagram of the U-Net architecture used to predict the lenticule boundaries. The rectangles represent how the feature maps change inside the network: the height of the rectangle represents the spatial resolution of the feature map whereas the width represents the feature dimension.

To train the neural network, the *binary cross-entropy* (BCE) loss was used, as is the natural choice when dealing with binary classifications (Bishop, 2006), (Goodfellow, 2016). Since the lenticule boundaries are considered to be just one pixel wide, while the rest of the lenticule is 12 to 19 pixels wide, the ground truth data is rather imbalanced. Despite such imbalance, the experiments showed that introducing sample weights in the loss function does not improve the quality of the prediction, and thus a standard BCE loss was adopted.

The whole deep learning pipeline has been implemented using the *PyTorch* library (Paszke, 2019). The U-Net architecture employs a *Resnet* encoder pretrained on *ImageNet* from the *Segmentation Models* package (Yakubovskiy, 2020). We trained the network with the *Adam* optimizer with an initial learning rate of 0.001 for 32 epochs.

Color reconstruction

The task of the U-Net neural network was to accurately localize the lenticular boundaries. The best way to evaluate the success of the localization is to visually judge the resulting color image. This requires performing the second step of the color reconstruction process, i.e., the conversion of the gray levels into color.

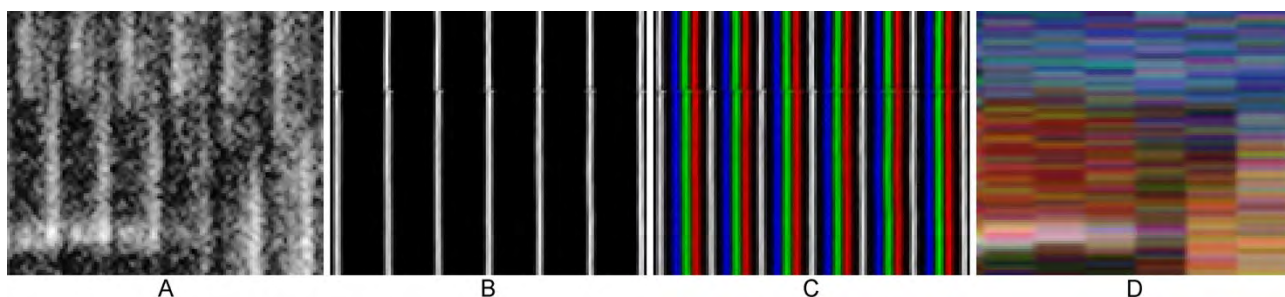


Fig. 5 – The color reconstruction process – The input image (A), the probability map determined by the U-Net (B), the weights given to each pixel of the input image for the R, G and B channels (C), and the final color image (D).

The output of the U-Net expresses the probability that a given pixel belongs to the boundary class. With the predictions of lenticules' locations (Fig. 5-B), we can extract the RGB information by selecting the values of the input grayscale image (Fig. 5-A) at the right spatial locations (Fig. 5-C). The extracted RGB values correspond to the color of the reconstructed image for all the pixels localized within the lenticule in the specific row (Fig. 5-D).

All the operations required for the colorization process can be seen as a series of convolutions and pixelwise operations starting from the neural network lenticules predictions and the grayscale input image. The color reconstruction step is implemented using the *PyTorch* library. The color reconstruction of a film frame takes a few seconds on a modern GPU.

Evaluation of the results

The new software deep-doLCE was evaluated on one hundred images that were not included in the training dataset. The four examples reported in Fig. 6 well represent the success rate of deep-doLCE. The evaluation set also included images for which the original doLCE provided not fully convincing results due to not perfectly straight lenticules (e.g., Fig. 6 – frames A2 and A4), and images for which doLCE misplaced some lenticules creating evident flaws (e.g., frames A1 and A3). Deep-doLCE properly reconstructed the colors of all these images (see corresponding frames B). Some minimal artifacts might still be present in some cases, but the colors are overall convincing. The residual artifacts, as for instance the greenish sky at the edge of the B2 frame, might be part of the color encoding during film shooting, and should not be necessarily considered as a bad reconstruction if we prioritize the authenticity of the digitization, which must recreate the original experience during analog projection (Trumpy *et al.*, 2018).

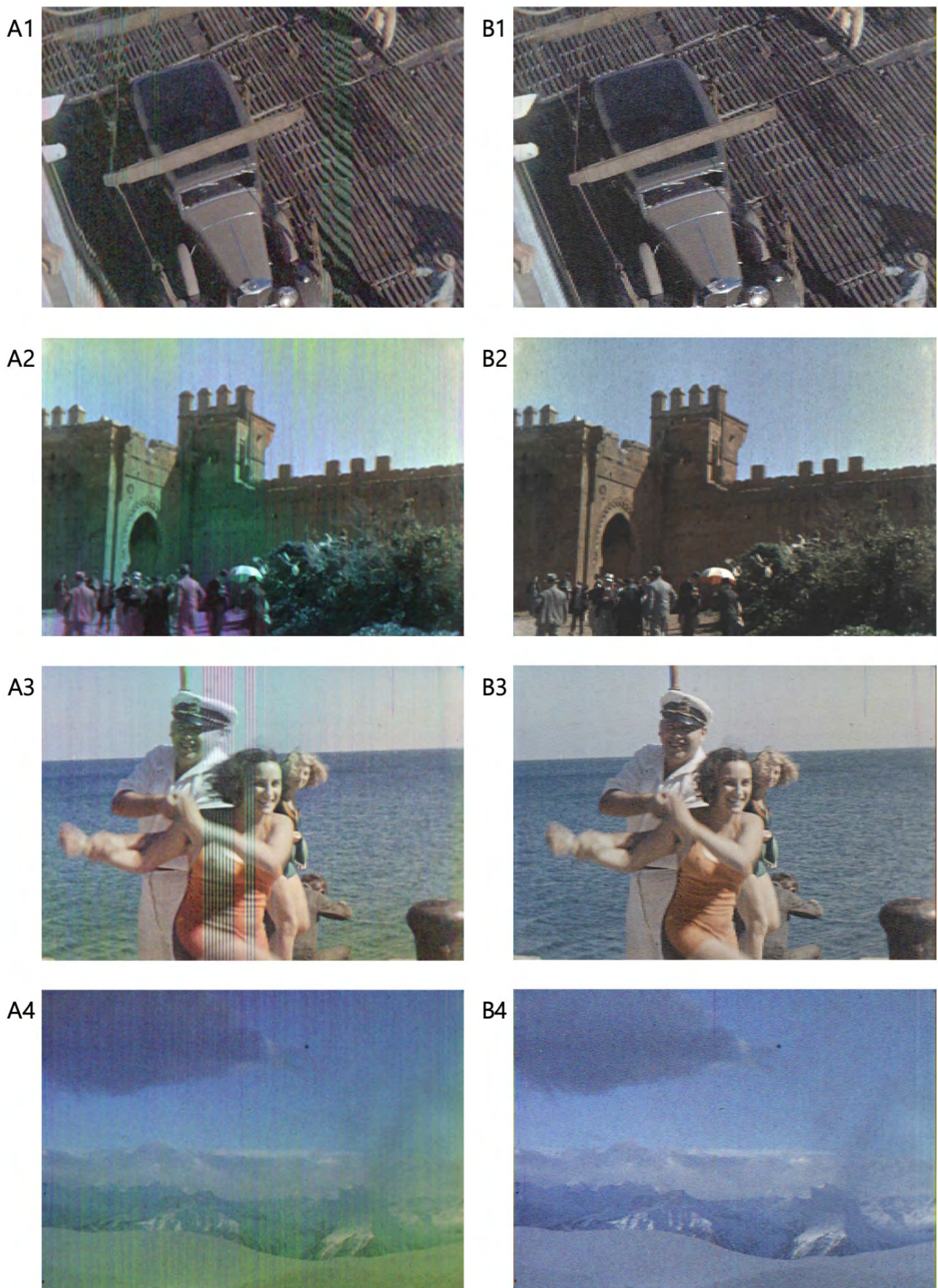


Fig. 6 – Left - Color reconstructions with doLCE (frames A1-4). Right - Corresponding result with deep-doLCE (frames B1-4).

Conclusion

Deep-doLCE provides a new modern tool to access the color of lenticular films. The software is robust and successfully localizes the lenticular screen, thus allowing to obtain convincing colors. As soon as the testing phase will be completed with more lenticular films, and the computational pipeline for final look of the color image is finalized, the software will be made available as an open-source project on publicly accessible repositories (e.g., GitHub, GNU Savannah). This will revive awareness of this special color process, aid its positive identification, and promote its proper digitization.

Acknowledgements

The present work leverages the fundamental concepts developed by Rudolf Gschwind, who initiated the doLCE project. Chenfei Fan gave a relevant contribution to the definition of the network architecture. The investigations on lenticular film conducted by David Pfluger and Lutz Garmsen were essential to achieve the presented results. The research would not be possible without the trust and support from Barbara Flueckiger. Special thanks go to the institutions and private collectors who provided the films used in the experiments: Agentur Karl Höffkes, Stiftung Deutsche Kinemathek, Cinémathèque suisse, Lichtspiel / Kinemathek Bern, Ralf Klee. The research is supported by the Hasler Foundation.

Bibliography

- Aschenbach, T. (2013) ‘Digital Color Decoding of Kodacolor Film’. *Reel Thing XXXII*, Richmond, VA, 4 November.
- Bishop, C. M. (2006) *Pattern recognition and machine learning*. New York, NY: Springer.
- Capstaff, J. G., Miller, O. E. and Wilder, L. S. (1937) ‘The Projection of Lenticular Color Films’, *Journal of the Society of Motion Picture Engineers*, 28(1), pp. 123–135.
- Goodfellow, I., Bengio, Y. and Courville, A. (2016) *Deep Learning*. Cambridge, MA: MIT Press.
- Gordon, M. (2013) ‘Lenticular Spectacles. Kodacolor’s Fit in the Amateur Arsenal’, *Film History*, 25(4), pp. 36–61.
- Paszke, A. *et al.* (2019) ‘PyTorch: An Imperative Style, High-Performance Deep Learning Library.’, in *Advances in Neural Information Processing Systems 32: Annual Conference on Neural Information Processing Systems 2019*, NeurIPS 2019, pp. 8024–8035.
- Reuteler, J., Fornaro, P. and Gschwind, R. (2013) ‘Digital Color Reconstruction of Lenticular Film: Project “doLCE”’. *ARRI Archive Workshop*, Munich, D, 11 June.
- Reuteler, J. and Gschwind, R. (2014) ‘Die Farben des Riffelfilms. Digitale Farbrekonstruktion von Linsenrastrerfilm’, *Rundbrief Fotografie*, 21(1/2, 81,82), pp. 37–41.
- Ronneberger, O., Fischer, P. and Brox, T. (2015) ‘U-Net: Convolutional Networks for Biomedical Image Segmentation’, in Navab, N. *et al.* (eds) *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015*. Cham: Springer International Publishing, pp. 234–241.
- Sudre, C. H. *et al.* (2017) ‘Generalised Dice Overlap as a Deep Learning Loss Function for Highly Unbalanced Segmentations’, in Cardoso, M. J. *et al.* (eds) *Deep Learning in Medical Image Analysis and Multimodal Learning for Clinical Decision Support*. Cham: Springer International Publishing, pp. 240–248.
- Trumpy, G., Diecke, J., Gschwind, R. and Flueckiger, B. (2018) ‘Cyber-Digitization. Pushing the Borders of Film Restoration’s Ethics’, *Electronic Media & Visual Arts*, Conference Proceedings, 2018, pp. 190–195.
- Yakubovskiy, P. (2020) ‘Segmentation Models Pytorch’, *GitHub repository*, Available at: github.com/qubvel/segmentation_models.pytorch (Accessed: 17 May 2021).

In the face of the Typhoon 19: a report on salvaging the Kawasaki City Museum's photography and film collection

Kanako NAKANISHI, Kanako NAKANO

Kawasaki City Museum, JAPAN

Kanako NAKANISHI (Curator for film) : nakanishi_k@kawasaki-museum.com

Kanako NAKANO (Curator for photography) : nakano_k@kawasaki-museum.com

Abstract

On October 12, 2019, the Typhoon 19 / Hagibis which landed in Japan caused severe damage to wide areas in eastern Japan. This extremely violent and large tropical cyclone had affected Kawasaki City Museum as well, which is located along with the Tama River in Kanagawa prefecture. It harmed 230,000 items which were stored in the nine underground storages (except for the 31,000 items that were not stored in the basement). This report will share how the museum dealt with the disaster damages focusing on the photography and film collection including the processes of salvaging and preserving the artworks as well as the multiple cases of damaged photography and film caused by inland water flood.

Keywords: museum, photographic collection, film collection, flood, emergency treatment, preservation, disaster management.

Introduction

Kawasaki City Museum is a cultural complex of history and art with its basic theme of 'The City and Its People' which has opened in 1988. The museum presents the history and progress of the city of Kawasaki on the one hand, illustrated with archeological, historical, and folk exhibits; and, on the other, modern and contemporary artistic expressions with exhibits of posters, photographs, manga, films and videos by artists who have drawn inspiration from the urban environment of Kawasaki and other cities. The museum's collection embraces wide range of media from historical documents, earthenware to painting, drawing, prints, manga, photography, and film.



Fig. 1 - . Kawasaki City Museum

1. Overall damage to the museum

On October 12, 2019, the Typhoon 19 / Hagibis which landed in Japan caused severe damage to wide areas in eastern Japan including Kawasaki City Museum. According to Ministry of Land,

Infrastructure, Transport and Tourism who helped the museum with the drainage of the water have reported that they drained 50,000 cubic meter of water in four days. It harmed 230,000 items which were stored in the nine underground storages (except for the 31,000 items that were not stored in the basement). On salvaging film and photography works, time is critical. Consulting with several experts, it has been decided as a plan that salvaging photography and film collection as the most urgent matter. However, it took six days to have access to the basement floor to drain out the water as well as move the various drifted objects. Finally, on October 22nd, the first action had begun with carrying out the film negatives. Followingly, with the support from many organizations such as The Japanese Council of Art Museums, National Institutes for Cultural Heritage, and The Japan Society for the Conservation of Cultural Property, the salvaging the collections for all the departments have started. From around early 2020, with the Covid-19 pandemic, since it became impossible to get help from supporting organizations in person, the pace of our salvation had to slow down. But finally on June 19th, 2020, all the items stored at the underground basement got evacuated. Since then, we have started to get in the phase of repairment and conservation.

2. Salvaging Film Collection

The film department of the museum functions as one of the five public film archives in Japan. (There are also private film archives as well as the film archive in the educational institutions.) The main core of film department's collection is the independent Japanese cinema and documentaries from around 1950s to 1990s such as the works by Fumio Kamei and Toshio Matsumoto. The materials of the collection include the celluloid films as well as non-film items such as set design sketches, scripts, posters, and ephemeras. But for this paper, it will only focus on the rescuing of the films.

It was the first time for a film archive in Japan to have such a huge damage from natural disaster. Compared to the paper-based items, film as a media is comparatively new and no other institutions have been in similar situation in the past, it was a big challenge for the film department to build the network itself through contacting and connecting to the archives and archivists for the rescuing the films. Therefore, as a film department, there were multiple obstacles in terms of technical solutions as well as institutional supports and networks.

In this sense, we are so grateful to get the big support from National Film Archive of Japan where they not only gave us advice but help us during the first aid in person. Also, the film archivists in Japan including Film Preservation Society's Film Salvation Project.



Fig. 2 - . A submerged film roll which got deformed due to the expansion of the film emulsion

In salvaging the films, we had around 2,000 film titles in the basement, which was impossible to save them all at the same time, so we had come up with the triage to rescue the negatives and unique pieces of 8mm first. For the first aid, we have shipped them to the four domestic labs. There are only four companies in Japan right now where they can rewash 35mm films. We shipped the unreprintable

films to the labs. For the rest of the films, we moved the films outside of the storage, rinse them with clean water and had to dry them as it is.

For the first aid at the lab, the developing machine was sometimes used as a substitute to rewash films.

After the rewash, consulting with National Film Archive of Japan and the film archivists, we came up with the measurement of the water damage for the further treatment. Instruction is to observe a film roll in 3 aspects. "Water damages", "Condition of Emulsion", "Condition of base"

With these observations, we categorized the film into 5 stages of Damages.

- A : Did not submerge, does not require a special treatment
- B : Seems to have submerged, but the condition is not bad
- C : Submerged, and the emulsion seems to have expanded, but most of the emulsion is still on the base
- D : Submerged, emulsion started to peel off, blocking can be seen, and some part of the film is impossible to salvage
- E : Submerged, emulsion started to peel off, blocking can be seen, and most of the frames are impossible to salvage

After the rewash, we thought things will be alright for a while, but some of the films remained to have strong odor as if something is rotten. Since we were planning to store these films with the normal conditioned films, we feared that these water damaged films may have affect other films. So, with the support from Independent Administrative Institution National Institutes for Cultural Heritage, Tokyo National Research Institute for Cultural Properties, we surveyed the organic activities on film roll using the special machine on the left picture called ATP (adenosine triphosphate) measuring instrument. This machine is usually used at the soy-sauce factory. If there is a life form activity, the number get higher. With this survey, no activity was confirmed.

After these first aids phase, we will be facing other tasks in preserving and conserving films. One of the biggest challenges is how to digitize the water damaged films.

3. Salvaging Photographic Collection

The museum has a photograph collection eminent in Japan. There were over 8600 works, including the collection of 100 Japanese photographers after the war. For example, Ken Domon, Hiroshi Hamaya, Toyo Miyatake, Eiko Hosoe, Daido Moriyama, and Masahisa Fukase. We also have works by renowned photographers from the world such as Eugène Atget, Lewis Wickes Hine, and Lewis Baltz. We also own photographs taken during Sino-Japanese War (1894-5) and Russo-Japanese war (1904-5). We hold a wide range of photographs, from Daguerreotype to Inkjet print, from 19th century to Contemporary.

The storage of our photographic collection was flooded above 2.5 meters. The collection was under the water for 3 days. It was only after 2 weeks when we were able to step into the storage, on October 25th. The emergency treatment has started on October 26th and it took us 1 year to rescue 8600 works.



Fig. 3 -. Basement storage 8- 31 October 2011

The environment and situation of the storage were not easy for the curators to work. The humidity level was as high as 100%RH, the bad smell was unbearable, and the floor was slippery from dirty water. The surface of gelatin silver prints and dye transfer prints were completely melted, and mould was growing. The exception was albumen prints, which kept their images. For that reason, we decided to put them as priority for the emergency treatment.

Such a large-scale rescue concerning the public collection of photographs had been the first time in Japan. The initial response was divided in 3 parts:

1. Triage...planning the emergency treatment before the condition check. It was something we have never been experienced and the triage was beyond imagination.
2. Coordinating the emergency treatment plan...Method, place, staff, supplies, and costs.
3. Administrative procedure...Request for help to the experts, organization of specialist team.

The biggest problem was the third part, “administrative procedure” which was simply “How can we request to help?”. As we are a public museum run by municipal government of Kawasaki City, each procedure had to be evaluated and documented by the Kawasaki City.

For carrying out emergency treatment, in order to request an expert, or make the important decisions, we needed a prior agreement with the administration section of the City. We faced problems that we didn't have the experience of how to deal with and what steps should be taken to request expert's help in this situation. To start the emergency treatment involving help from other people, we needed an official request letter and contract from the Kawasaki City.

To make emergency rescue plans, it was necessary to get treatment proposal and estimate costs. Treating public collection within administrative processing by City or Prefecture, we had to seek external institution for actual help and rescue and not to volunteers. This was because it was easier for the city to make decisions based on proposals and estimates given by public organizations with some advice from experts on photographs.

Conclusion

In the future, sadly, we can not say that we will not expect to face the same natural disaster. By sharing our rare cases of our experiences, we hope that our experience will be useful when dealing with flooded materials.

Image Quality Metrics for Digital Film Restoration

Majed Chambah

CReSTIC, Université de Reims Champagne-Ardenne, Reims, France

majed.chambah@univ-reims.fr

Abstract

Many digital film restoration techniques have emerged during the last decade and became more and more automated, but restoration evaluation remains a rarely tackled issue. In the sphere of cinema, the image quality is judged visually. In fact, experts and technicians judge and determine the quality of the film images during the calibration (postproduction) process. Consequently, the quality of a movie is also estimated subjectively by experts in the field of digital film restoration. On the other hand, objective quality metrics do not necessarily correlate well with perceived quality. Plus, some measures assume that there exists a reference in the form of an “original” to compare to, which prevents their usage in digital restoration field, where often there is no reference to compare to. That is why subjective evaluation is the most used and most efficient approach up to now. But subjective assessment is expensive, time consuming and does not respond, hence, to the economic requirements. After presenting the several defects than can affect cinematographic material, and the film digital restoration field, we present in this paper the issues of image quality evaluation in the field of digital film restoration and briefly present an AI based image quality assessment system.

Keywords: *digital film restoration, image quality.*

Introduction

The motion pictures represent an important cultural heritage. As films age they became prone to all kinds of defects such as dust, scratches, vinegar syndrome and colour dye fading. Several film defects such as dye fading and vinegar syndrome are chemically irreversible processes (Reilly 1998, EBU 2001) and often a degraded version is the only available record of a film, hence the importance of digital film restoration. In fact, beside the fact that it can tackle artifacts that are out of reach of traditional photochemical restoration techniques, digital film restoration presents the advantage of not affecting the original material, since it works on a digital copy.

Several digital restoration techniques (Chambah, 2002; Chambah, 2003; Buisson, 1997; Joyeux, 2001; Besserer, 2004; Kornprobst, 1998; Decenci re, 1997) have emerged during the last two decades and became more and more automated but restoration evaluation remains still a rarely tackled issue (Chambah, 2004; Decenci re, 2001).

Some caution must be exercised when doing quality assessment in the field of restoration. The material to be restored is not coming from a stable technological process that would produce the same basic quality before any degradation. The cinematographic technological methods have not changed notably since the beginning of cinema exploitation, keeping the same basic camera and projector movements, the same format size, the ubiquitous 35mm film, and similar laboratory procedures, but the quality has always evolved.

Even if we disregard the relative statistic dispersion of quality due to different working standards and accidental variations, there has been a constant change of quality.

Moreover, the historical evolution was not a continued regular improvement towards higher standards. For example, in the early days of colour film, economic reasons were a motive to abandon the high-quality Technicolor process using three or two strips of film. As a result, there was a loss in quality not only in resolution, because of the combination of the three colour layers on one strip of film, but also a loss in the gamut of colour covered by the system, because of the complicated chemical process used.

It is therefore probably not a good choice to use absolute reference metrics when assessing the quality of a specific film. Knowledge of the historical evolutions of the technology suggests that it

would be necessary to use historical reference metrics in this case, a puzzling problem. The use of reference free metrics would then be a better choice in the context of automation.

Thus, reliable automatic methods for visual quality assessment are needed in the field of digital film restoration.

Ideally, a quality assessment system would perceive and measure image or video impairments just like a human being.

Film degradation

The goal here is not to present an exhaustive list of defects. It would be too long, boring, and rather confusing. Moreover, there is more than one way to present such a list. The point of view of the librarian does not coincide with the point of view of the image processing specialist. In order to avoid a lengthy and possibly controversial enumeration, we will use a structured approach that we claim is better suited for the problem at hand.

Defects affecting the photochemical material: A film is built of a photochemical emulsion deposited on a base. The base must hold firmly the emulsion, stay chemically neutral for this emulsion, stay flexible, avoid deformations and resist to all the environmental and mechanical constraints that the technology imposes on the film: Tight loops during shooting and projection, strong tension during rewinding or laboratory work, immersion in various chemical baths for processing, sudden heating during projection. After all this treatment it must stay in good condition for long period of storage.

Mechanical degradations: The first degradations that the film must endure are caused by improper handling. Even a repeated normal handling of a film is causing a few problems.

The main phenomenon is abrasion caused by the dust or by a mechanical protruding piece of fabric in camera, projector or any mechanical device used during the long life of a film.

Dust, dirt, and thin scratches: The dust is causing thin scratches on film and small particles of dust may penetrate the film base or the emulsion. It is a well-known fact for film professional that the beginning and end of every spool is more degraded than the middle. This is because of the manual manipulation of the spools during editing, control, or projection, causing both tails of the film spool to float for some moment in rooms and to rub all possible surfaces.

Elongated scratches: Protruding pieces of metal or small defects on metal surfaces, mainly in the camera during shooting, or later in the various equipment is causing the elongated vertical scratches which run along many frames.

Jitter (Image vibrations): Repeated loading, unloading, winding, and rewinding of the film strips is also damaging the film holes that are supposed to guaranty a stable repeated positioning of the images during projection. When the holes are deteriorated the strong mechanical tensions and alternating movements of the projection are causing an irregular positioning of each frame. But it is also true that early film strip and old camera movement were not as stable as today and were also causes of the same kind of jitter.

Missing parts and missing frames: A severe mistreatment of the film strip or repeated careless manipulations may cause tears and breaks of the strip.

Chemical degradations of the base: Historically three successive materials have been used for the film base: Cellulose nitrate, cellulose acetate and polyester. Unfortunately, each of these materials has some drawback. The first base used was highly flammable and could even detonate. In fact, cellulose nitrate enters in the composition of the dynamite. The main problem with the cellulose nitrate is a reaction with the metallic boxes used to store the film spools. The parts in close contact with the film become brittle and disappear in dust. Fortunately, it does not harm too much the emulsion. In almost all the developed countries nitrate films have been copied to safer film system. Cellulose acetate base films, also called "safety" films, were developed in order to get rid of the flammability problems of the first films. Unfortunately, the new base proved not to be totally safe, and it is a general sad rule that each new product developed to cure former problems is exhibiting its own set of problems.

Vinegar syndrome: Is a degradation that affects film material using a cellulose acetate base. It is the hydrolysis of acetate groups which results in the formation of acetic acid (vinegar). This chemical degradation allows also easier access to moisture. The acetic acid increases the rate of hydrolysis and so the hydrolytic degradation assumes an auto-catalytic nature. At the end the base is dissolved and the emulsion remains alone. There is not much to be done at this stage. The main problem at earlier stages is a deformation of the support which causes variable local blurring effect. This problem has been addressed by a digital restoration method explained in (HeIt, 2001). The current new base in use is made of polyester. It is much stronger and resistant to mechanical tension and tearing. There are not yet confirmed reports of specific degradations.

Chemical degradations of the emulsion: The emulsion is supposed to be stable once the chemical processing has been completed. For black and white films there is not much risk of degradation if the laboratory work has been done with sufficient care. A good number of very old black and white films have been kept in good conditions for more than a hundred years now.

Contrast saturation: A common degradation seen in old black and white films is the strong saturation of the black and of the white areas with a severe loss of middle tones.

Colour dye fading: But the complex chemical composite of the emulsion in colour film is more sensible to the influence of radiation temperature and humidity. Colour fading is caused by chemical changes in the image dyes of colour films. Many older films have taken on a distinct colour cast, caused by the rapid fading of one or two image dyes. Colour negative film, colour slide film, colour print material, interpositives and colour motion-picture release print film are all affected in the same way. The fading of one or two chromatic layers of the film results in a drab image with poor saturation and an overall colour cast.

Film reproduction degradations: The reproduction mechanism of the cinematographic film is done by optical duplication. Even conducted with special care this operation is provoking degradation in resolution.

Blurring effect: The film projected in cinema theatres is a third generation copy of the original negative used for shooting. From this negative a first interpositive is printed, and then an internegative is obtained which is the base for numerous copies called release prints. A test exposed in the SMPTE Journal of February March 2004, is measuring the relative loss of quality between the original negative and the release prints. A rough measure of degradation may be derived from the MTF curves by stating that the resolution is divided by two.

Halo: During the printing operations several other degradations may occur. An improper adjustment of the lighting is causing halos or uneven distribution of the intensity in each frame.

Fog: An incomplete isolation from interfering lights may cause a fog effect. In general, this effect is stable and must not be confused with the moving fog effect caused by an incomplete mixing of the chemicals during processing.

Flicker: Several mechanical misalignments during the optical printing may have also caused the phenomenon called flicker. The overall image intensity is varying from frame to frame. It is difficult to distinguish this from the flicker present in old shooting and caused by the irregular speed in the camera movement.

Issues in restoration evaluation

In the traditional photochemical world, in order to evaluate the state of a film for restoration or to assess its quality of conservation, it is only necessary to have a look at it. A quick examination of the base gives an indication of its aging conditions. A projection is the only way to judge the quality. The film itself is the recording support (the base), the recording method and medium (the emulsion), the storage medium, the viewing support, and the reproduction support.

The digital film is dissociated from the recording, viewing, and storing methods and supports. The digital code is not the viewed image; it is only the algorithmic potentiality of an image, when arranged and transmitted for display. The examination of the code itself does not indicate if there are defects, because the code itself is built to stay unaffected through multiple copies by virtue of its

algorithmic nature. It is only because the digitally coded image is the representation (translation) of a bi-dimensional arrangement exhibiting such and such regularities that it is possible to speak of defects and to evaluate a quality. These regularities, defined a priori, are those of a photochemical image recorded by a specific camera, reproduced by some laboratory process, kept on a certain base and digitized on a specific modern system. All these equipment have their characteristics and the processes took place at certain dates and all this may be known or not. We have seen all the transformations and degradations which are occurring to the film up to, and including, the digitization. The question of how to evaluate the quality of a digitized film may be addressed by considering the questions of control strategy, microstructures, and macrostructures.

Control strategy: The first consequence of the separation of the code from the support is the necessity for a control strategy quite different from the traditional one. It seems evident that the digitization process must be fully analysed, and all its characteristics documented in full details. We have seen earlier how the coding domains are different and may give rise to quite different quantization noises for example. The earlier techniques may not be known and may be only approximately dated, but this stage at least must be imperatively known. The basic characteristics are the sampling method and dimension, the encoding domain, the original quantization. This may also include knowledge of the characteristics of the film being digitized.

The nature of the film is important because negative or positive film have different contrast. The colour process is also interesting; it gives an indication of the possible colour gamut. The sampling of a piece of film without any image impressed on it gives indication of the density of the base, the absolute minimum density. Lastly a sampling of a moderately dense flat image gives an indication of the grain size. Moreover, if a quick look at the film base is enough to judge of the conservation quality of one spool, there is nothing comparable in the digital world. It seems therefore imperative to do a search through all the images of the film or at least through a subset offering all the conditions for completeness of control. This is the condition for being able to know precisely the full range of the individual characteristics, amount of noise, grain characteristics, maximum contrast range, largest colour gamut, etc.

Degradations or artistic distortions? A complete and thorough control strategy cannot solve everything. Another difficulty is coming from the artistic nature of the cinematographic work. Contrary to an industrial controlled environment, the artistic nature of the film work is generating considerable variations in the characteristics of the recorded images.

This is creating some puzzling problems for the quality assessment. An example will illustrate clearly this point. If one is doing quality control on numerous sample images and finds a certain part of a film to be affected by a specific colour problem. This part exhibits the same grain and noise values than the rest of the film. The scene compositions are not differing from any other scenes. But the contrast level is slightly less important, and the colour saturation is low with a general blue dominant colour. Is this a defect? A professional look at the sequence shows that it is a group of "day for night effect" scenes in the film. But surely it could have been a bad copy or a bad transfer. How to solve this puzzle? One possible answer to this question is to look at the structure of a film. If the transitions between normal quality scenes and scenes having this specific distortion are happening at the same location than the film scene transitions, it is certainly an artistic choice.

Microstructures and macrostructures: We have seen that the structure of the film could guide the quality evaluation process. The Technicolor process example given in the introduction will serve to further illustrate the conclusion of the previous section. We were stating that the abandon of the high-quality Technicolor process resulted in a loss of quality in resolution but also in the colour gamut of films. We see here two different kinds of qualities which must be treated separately.

It is certain that digital processing may give useful indication when considering the characteristics of noise grain size maximum gradient contours and measures of the same sort. Those are the measurable microstructures of the images.

But when it comes to different qualities like the colour gamut, the contrast, the luminance, the colour dominant, we are considering qualities that are relating to perception and to artistic

expression. We must exercise some caution while measuring these characteristics. Their evaluation requires some knowledge of the technical representation systems and of their possible artistic or semantic usage. Without having to investigate fully in the semantic aspects of film, it is probably enough to subordinate the interpretation of these measures to the visible construction of the film. The editing, the scene content to some extent and the camera movements are often macrostructure which may help prevent misinterpretations of the measures. It is interesting to note that these macrostructures are not too difficult to detect automatically.

Cinema image quality evaluation: In the sphere of cinema, the image quality is judged visually. In fact, experts and technicians judge and determine the quality of the film images during the calibration (postproduction) process. Consequently, the quality of a restored movie is also estimated subjectively by experts.

On the other hand, objective quality metrics do not necessarily correlate well with perceived quality (Wang, 2002). Plus, some measures assume that there exists a reference in the form of an “original” to compare to, which prevents their usage in digital restoration field, where often there is no reference to compare to. That is why subjective evaluation is the most used and most efficient approach up to now. But subjective assessment is expensive, time consuming and does not respond, hence, to the economic requirements. Thus, reliable automatic methods for visual quality assessment are needed in the field of digital film restoration.

Ideally, a quality assessment system would perceive and measure image or video impairments just like a human being. Two approaches can be taken:

- The “psychophysical approach” or “human visual system approach”, which is based on models of the human visual system (Winkler, 2000). Their general structure is usually determined by the modeling of visual effects, such as color appearance, contrast sensitivity, and visual masking, to name a few. Due to their generality, these metrics can be used in a wide range of applications; the downside to this is the high complexity of the underlying vision models. Besides, the visual effects modeled are best understood at the threshold of visibility, whereas image distortions are often supra-threshold.
- The “engineering approach” or “imaging system approach”, where metrics make certain assumptions about the types of artifacts that are introduced by a specific compression technology or transmission link. Such metrics look for the strength of these distortions in the video and use their measurements to estimate the overall quality.

Based on the latter approach, a few studies of restoration quality (mainly on black and white films) are emerging (Decenci re, 2001), in order to characterize the impairments to detect (like dust, flickering and scratches). Only limited success has been achieved. This is due to factors like the absence of reference to compare to, the difficulty to characterize precisely the impairments affecting films, the high definition of images that makes defects very visible, the spatiotemporal dimension of the images to restore, and to the lack of correlation between the metrics and the perceived quality. In fact, a metric may indicate that a scratch is less prominent after its correction, but perceptually an ill corrected scratch offends more than the original scratch, since we have been used during decades to see scratched movies. This example illustrates the complexity of some perception mechanisms and the difficulty to set measures that correlate these mechanisms.

AI based reference free quality assessment

The aim of automatic image quality assessment is to replace human judgment of perceived image quality with a machine evaluation. Avoiding inputs from human subjects can lead to deterministic models, yet objective systems should keep human scores as references to ensure consistency with subjective results. The developed system aims at assessing the perceived quality automatically when an enhancement algorithm is applied on an image. It is based on reference free approach. Figure 1 gives a schematic representation of the overall system. The model operates on numerical features extracted only from the image at test, that are used feed the neural network to obtain the quality rating.

The subsystem consists of two main parts: feature extraction and an artificial neural network as a combiner. The set of extracted features used to assess the image at test are different designed metrics: Clearness (number of pixels on the edges of the image, mean lightness value on the edges of the image), contrast (global contrast, local contrast), lightness (mean lightness of the image, entropy of the distribution of the lightness, standard deviation of the lightness) and colour (scatter of the colour dominant, proportion of the colour dominant, spatial scatter of the colour dominant).

In order to train and then evaluate the performance of the proposed model, we need the set of Mean Opinion Scores (MOS) of subjective image quality tests obtained by a group of human observers.

After the system was trained, the system evaluates the quality of the image based on the extracted features (global image quality MOS) and computes the correlation with the MOS of subjective assessment. Our experimental results show that the correlation ratio can be up to 0,95 which is very promising. The aim of this paper is not going into technical detail and focus only on the main idea. Further details can be found in (Ouni, 2012).

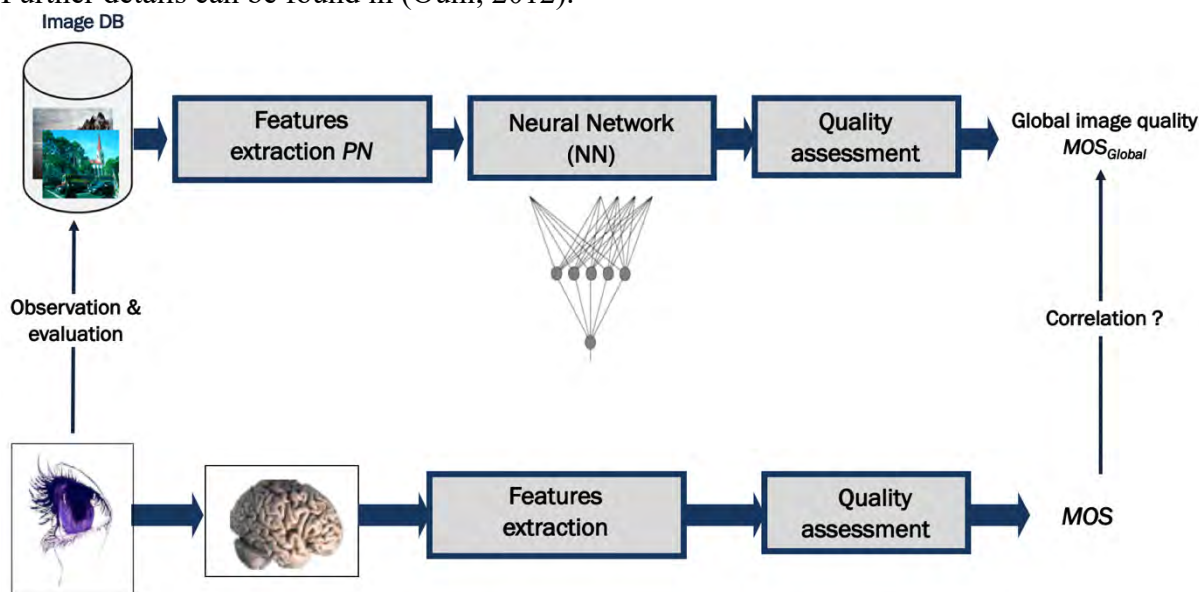


Fig. 1 Architecture of the proposed no reference subsystem based on neural network.

Conclusion

In this paper we have addressed the issue of image quality assessment in the field of digital film restoration field. We detailed the defects that affect films and the issues of quality assessment in the field of film restoration. We also briefly presented an AI based image quality assessment system. Even though the developed reference free metrics have shown their efficiency in helping assess objectively the image quality, in helping automatically fine tune restoration algorithm parameters and speed up restoration quality estimation, human validation is still needed and still a lot of research need to be done.

Bibliography

Besserer B., Thiré C. (2004). 'Detection and Tracking Scheme for Line Scratch Removal in an Image Sequence', *ECCV* (3) 264-275.

Buisson O., Besserer B., Boukir S., HeIt F. (1997). 'Deterioration detection for digital film restoration'. *CVPR*.

Chambah M., Besserer B., Courtellemont P. (2002). 'Approach to Automate Digital Restoration of Faded Color Films', *IS&T Conference on Graphics, Imaging, and Vision CGIV 2002*, Poitiers, France, pp. 613-618.

Chambah M., Besserer B., Courtellemont P. (2002). 'Latest Results in Digital Color Film Restoration', *Machine Graphics and Vision* (MG&V) Journal.

Chambah M., Rizzi A., Gatta C., Besserer B., Marini D. (2003). 'Perceptual Approach for Unsupervised Digital Color Restoration of Cinematographic Archives'. *SPIE / IS&T Electronic Imaging 2003*, Santa Clara, CA, USA, vol. 5008, pp. 138-149.

Chambah M. (2004). 'Automatic Color Restoration of Faded Pictures and Motion Pictures'. *The 8th World Multi-Conference on Systemics, Cybernetics and Informatics SCI 2004*, Color Image Processing & Applications invited session, Orlando.

Decenci re E. (1997). 'Restauration automatique de films de films anciens'. *Ph.D Thesis*, Ecole Nationale sup rieure des Mines de Paris.

Decenci re E., (2001). 'Restoration Quality Assessment'. *IEE Seminar on Digital Restoration of Film and Video Archives*.

EBU (2001) European Broadcasting Union. 'Preservation and reuse of motion picture film material for television: Guidance for broadcasters'. *TECH 3289-E*.

Joyeux L., Boukir S., Besserer B., Buisson O. (2001). Reconstruction of degraded image sequences. Application to film restoration', *Image Vision Comput.* 19(8): 503-516.

Kornprobst P., Deriche R., Aubert G. (1998). 'Image Sequence Restoration: A PDE based coupled method for image restoration and motion segmentation'. *Proceedings of 5th European conference on computer vision*, vol. 2, pp. 548-562.

Ouni S. (2012). ' valuation de la qualit  des images couleur application   la recherche &   l'am lioration des images'. *Ph.D Thesis*, Universit  de Reims Champagne-Ardenne, Universit  Tunis El Manar.

Reilly J.M. (1998). 'Storage Guide for Color Photographic Materials'. Albany, New York: The University of the State of New York, New York State Education Department, New York State Library, The New York State Program for the Conservation and Preservation of Library Research Materials.

Wang Z., Bovik A.C., Lu L. (2000). 'Why is image quality assessment so difficult?'. *IEEE International Conference on Acoustics, Speech, & Signal Processing*.

Winkler S. (2000). 'Vision Models and Quality Metrics for Image Processing Applications'. *PhD thesis*,  cole Polytechnique F d rale de Lausanne, Switzerland.

The long-term development of three-color Kodachrome. An odyssey from the additive to the subtractive method of color reproduction

Nicolas Le Guern, PhD¹

¹Independent researcher, Cokin KT s.a.s.u.

Contact: Nicolas Le Guern, nicolas.leguern@gmail.com

Abstract

The introduction of three-color Kodachrome in 1935 was possible thanks to the long collaboration between the independent inventors Leopold Mannes and Leopold Godowsky and the managers of the Kodak Research Laboratory at Rochester, New York. This paper considers this long research work initiated in 1917 by examining the technological solutions Mannes and Godowsky progressively followed, in the historical context of the first cinematographic additive processes. Besides the technological context, the paper analyzes the evolution of Mannes and Godowsky position into Kodak research. Working independently at the beginning, the two young men were funded by their families first, then by Eastman Kodak and Kuhn, Loeb & Co, experimenting in their personal laboratory. In a second step, Mannes and Godowsky were finally employed by Kodak in 1931 as consultant researchers and incorporated with the team of the Kodak Research Laboratory at Rochester. In the mid-1930s Mannes and Godowsky were able to develop a two-color cinematographic process, which finally evolved in the three-color Kodachrome process. This innovative process was announced in April 1935, despite the fact that the Kodak researchers did not succeed in finding a correct developing process for exposed films. An immense amount of work was done in the American laboratory to find a correct sequence of chromogenic development in the summer 1935. This long research odyssey ended when the Kodak research team managed to drastically simplify the developing process of exposed Kodachrome rolls in 1938, encouraged by the recent German competition and the Agfa Color Neu process.

Keywords: Kodachrome, Eastman Kodak, additive technology, subtractive technology, scientific collaboration, industrial research, Kodak Research Laboratory.

Introduction

With the long-term research undertaken by Leopold Mannes and Leopold Godowsky for a three-color multi-layer process, a new form of innovation took place at Eastman Kodak. It was the alliance between independent research and the industrial research organisation of one of the main film manufacturers of the period. Given the final result of the three-color Kodachrome released in 1935, this scientific collaboration can be judged as a positive, successful one. The research odyssey of Mannes and Godowsky between 1920 and 1935 was already studied and partially documented by Friedman (1944), Collins (1990), Coote (1993) and Brayer (1996) and I will only point out some events and milestones of their research work. My presentation will then clarify how an important teamwork was necessary at Kodak to work out a correct development process in 1935, and to simplify it 3 years later.

Early attempts with the additive technology of color reproduction

The legend indicating that Kodachrome was invented by two skilled musicians living far from science is wrong. Mannes and Godowsky were talented inventors who used a scientific background to transform the theory into a true process through experimentation. Godowsky studied chemistry, physics and mathematics at the University of California and Columbia University and Mannes received his Bachelor of Science degree in physics from Harvard in 1920 (Brayer, 1996, p.224; George Eastman House, 1964, p.15). The two men had met in school in 1916 and became friends with a mutual interest in photography. The next year, Mannes and Godowsky saw in New York a

film entitled *Our Navy* made with the Prizma I additive process. The colour rendering was not good and they started to undertake some research work at their high school to develop a better additive process. Prizma I had been developed by William Van Doren Kelley with the collaboration of Charles Raleigh, one of the inventor of the Kinemacolor process. Briefly, Godowsky remembered in an interview in the 70s that *Our Navy* was a two-color process only. However, this additive process used a rotary filter made of 4 color filters combined in pairs of complementary colors, so we could also see this process as a 4-color one.

Mannes and Godowsky started by improving a parallax issue encountered with multiple lens systems. They continued their research work during their holidays and managed to conceive a viable two-colour additive process. An experimental film was made but upon failing to adapt the projection equipment to the two-colour film Mannes and Godowsky gave up their first colour process (Collins, 1990, p.206). When they had graduated from University, they started to work full time as professional musicians but were still experimenting during their spare time on colour processes. At the beginning of the 1920s, they progressively turned from the additive to the subtractive theory, considering rightfully that the multi-layer film could be a better solution. In their makeshift laboratory at home, they managed to coat double-layered plates able to record part of the visible spectrum (Brayer, 1996, p.225). But they also worked on the theory of three-color photography and filed their first patent application in October 1921, to secure the making of a coloured positive from a set of separation negatives (Mannes and Godowsky, 1925).

I recently corresponded with the American artist and teacher of photography Matthew Gamber, who was one of the few to consult the industrial archive left by Godowsky at the George Eastman House. Gamber found photographic tests made with 3 separation negatives on black & white film using filters. He digitized each separation and combined the 3 files to create a final color photograph using an image processing software. The first result was a view of the Ansonia Hotel in New York from Mannes and Godowsky's apartment, where they installed a personal laboratory. The second image was a portrait of a young lady, identified by Gamber as a cousin-in-law of Mannes, the illustrator Helen Theresa Damrosch Tee-Van, daughter of Frank Damrosch.¹ This technique of three-color photography reminds us the process used by the Russian photographer Prokudine-Gorski.

The issue of funding and the progressive collaboration with Kodak

During this period, Mannes and Godowsky faced an important constraint. They had to seek funds to significantly improve their research work and results. In 1922 they were able to meet George Eastman directly to present their work on colour photography. Eastman was intrigued by their findings, but the meeting had no financial results (Brayer, 1996, p.225). Finally, the two researchers managed to contact the photochemist Kenneth Mees who was the first director of Kodak Research. During one trip to New York, the intrigued Mees met Mannes and Godowsky and was impressed by the progress of their photographic work. From then on and during the following years Mees accepted to supply them with the materials they would need for their research, especially some film coated with several layers (James, 1990, p.164-166; McCarthy, 1987, p.10; Brayer, 1996, p.225). The same year, Mannes had also approached a secretary of the investment firm of Kuhn, Loeb and Company. The two inventors gave a demonstration of their experimental process and managed to get a twenty thousand dollar loan from the firm.

The money was invested in the research and around one year later, Mannes and Godowsky filed another application for a two-colour negative process (Mannes and Godowsky, 1924). The new feature of the patent consisted in the method used for the development of the images : the diffusion into the gelatin of the solution used could be controlled at will. Thus one could develop only one layer

¹ I am very grateful to Matthew Gamber for providing me these images never published.

without polluting the other one. Mannes and Godowsky took care not to unveil any formula or detailed mechanisms of this controlled diffusion (Friedman, 1944, p.109-110). In 1925, The independent photochemist Edward J. Wall published his *History of Three-Color Photography* and Mannes and Godowsky knew that they were cited in the book for their 1924 patent (Wall, 1925, p.158; Coote, 1993, p.139). After the purchase of Wall's book, they discovered the scientific narrative of the monopack film and the potential of colour development.

Mannes and Godowsky were now working on a technology of *integral tripack* or *monopack*, whose structure was made of three layers each containing an emulsion sensitised for a single primary color. With Wall's book they read that a young independent photochemist Karl Schinzel was the first to patent the use of a subtractive monopack for color reproduction in 1905. However, this innovative process was theoretical and the few dyes available were not satisfactory to allow its practical use (Coote, 1993, p.134-135; Friedman, 1944). From 1927 on, Mannes and Godowsky conceived a different strategy for the colour development to get around the problem. Unlike other methods, they decided to include the colour couplers into the liquid developer instead of each emulsion layer. Thus the wandering coupler problem would be solved, but not the issue of the wandering sensitising dye (James, 1990, p.166; Collins, 1990, p.211).

In 1928, the chemist of the Eastman Kodak synthetic chemistry division Leslie Brooker was able to synthesise new dyes which were excellent sensitisers. The problem of wandering sensitisers was almost solved. The monopack concept could move from theory to practice. For Mees, the time to increase the scientific collaboration with Mannes and Godowsky had come.

The agreement seemed an easy one. The manufacturer offered to pay a lump sum of \$30,000, and annual salaries of \$7,500 each. The film manufacturer also accepted that Mannes and Godowsky would receive royalties on all patents filed before the collaboration with Kodak (Coote, 1993, p.139; Collins, 1990, p.211). The two independent researchers became incorporated in the Kodak research organisation in November 1930. First, they worked in a special laboratory at New York. After 1 June 1931, they started working at Kodak Park.

Finally employed by Eastman Kodak, Mannes and Godowsky probably had to adapt their research methods to the collaborative work with the Kodak Research Laboratory's staff. However this period is not well documented and it is difficult to ascertain the research work done and the practical terms of the collaboration. From 1930 on, the two inventors focused on processes involving mono-layer and mixed grain coatings to avoid the use of a multi-layer coating and its potential problems (Coote, 1993, p.140). As Mannes and Godowsky had a three-year contract terminating at the end of 1933, and as the results of their research were not visible enough, Mees had to insist with some members of Kodak Management that they should be given another chance for one more year. They finally developed a concrete two-colour cine film in 1934 (James, 1990, p.166-167). As the production of the new film was delayed due to some complications, Mannes and Godowsky were able to perform additional research and modified the two-color into a three-color process.

Market launch of a three-color film not yet finalized in 1935

Finally the new Kodachrome process in its 16mm version for colour movie was announced in April 1935. As the film consisted of five layers of emulsion and gelatine it was nicknamed the "quintuplet" film by *Science* magazine (Anon, 1935). Three layers were devoted to the recording of the blue, green and red spectrums. Between each sensitive layer a thin layer of clear gelatin was coated, used as a margin of safety during the development process and the use of the controlled diffusion bleach (Fig. 1). It was thus possible to bleach two layers and not the bottom layer. But the first development process was very long and involved in all 28 steps (Coote, 1993, p.142; Coe, 1978, p.128).

However, the correct development processing for the new Kodachrome film was not at all ready in April 1935. This situation was critical. It was possible to expose some 16mm Kodachrome reels but it was still impossible to get a neutral colorimetric rendering of the developed slides. Mees had to organize and supervise an exceptional program in extreme circumstances.

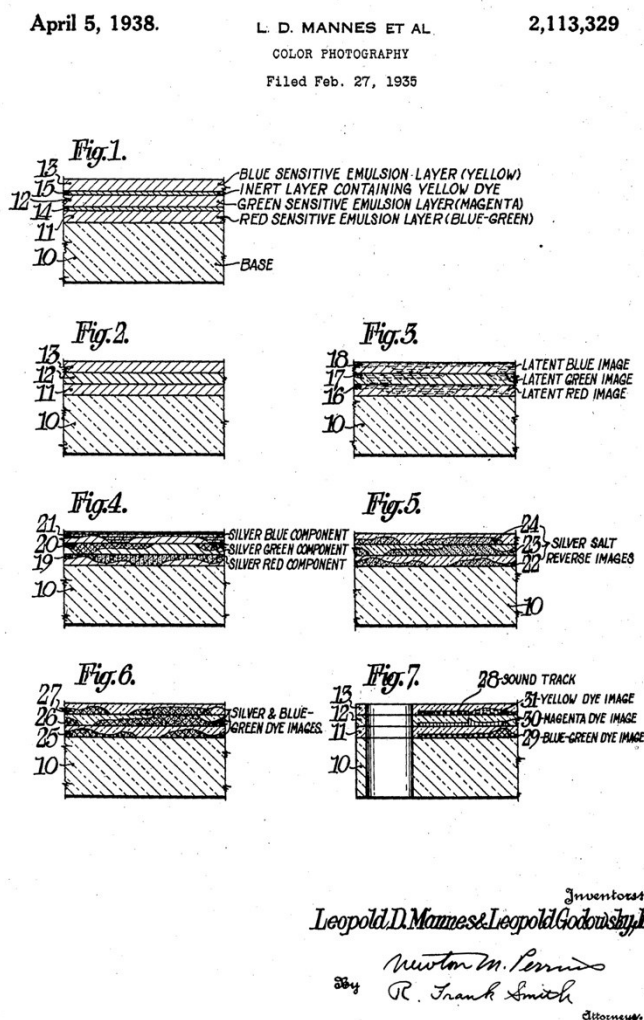


Fig. 1. Drawings from the American patent US 113329A « Color photography » filed by Mannes and Godowsky on 27 February 1935 and granted on 5 April 1938 (Espacenet, European Patent Office).

In one of his notebooks, the researcher Phillips detailed this critical period of intense research for a satisfactory development process. Phillips, a member of the Harrow Research Laboratory, was already visiting and working at Rochester in November 1934. In April and May 1935, he was testifying to the intensive work undertaken in the Research Laboratories. The teams were working nearly all day long with infrequent breaks in a desperate quest for better Kodachrome processing (Phillips, 1935). One day, Phillips reported that the general tendency of the experimental work was the development of Kodachrome with green neutrals. The photochemists tested several solutions to reduce the colour cast but, as the writer noted, the "results were very erratic" (14 May 1935, p.75) Some days later, the situation was better and the developed Kodachrome films at last reached a correct neutrality in the grey. This evidence of research teamwork illustrates well the complexity of the new Kodachrome process.

Chemical stability and color rendition of three-color Kodachrome version 1935-1938

Regarding this first version of Kodachrome film, it is challenging to estimate their photographic characteristic such as color rendition or stability of dyes (Fig. 2). Pénichon (2013) recently pointed out that original Kodachrome transparencies should not be projected due to their poor stability to light (p.204). Earlier, Siple (1951), a photographer and the creator of the American Museum of Photography, provided valuable information in his book *A Half Century of Color*. In the chapter about Kodachrome, Siple wrote:

‘The dyes in this earliest Kodachromes were not very stable, with the result that pictures made on the 1935 film have degraded and no longer retain the full colors as originally made. Just as this book goes to press [so we were in 1951] the American Museum of Photography has been presented with several rolls of 16mm Kodachrome motion pictures made in 1935 which show almost monochromatic pictures of a purple-magenta character.’ (p.142)



Fig. 2. Introduction of Kodachrome film in 1935 (Eastman Kodak Company, 1971:p. 13).

This clue points out that the yellow and cyan dyes in particular were less stable into the Kodachrome sandwich made and developed in 1935. Film rolls in color made during this period are really rare in the institutions, however a short film made in 1937 by the well-known photographer Man Ray provides some information about the nature of Kodachrome color rendering. According to Man Ray, he received an important quantity of Kodachrome rolls to test and a 16mm camera from Kodak, and we can assume that it was the French subsidiary of Kodak, the company Kodak-Pathé.² The result

² « Nous nous retrouvions sur une petite plage privée, La Garoupe, à Antibes. Kodak venait de mettre en vente une nouvelle pellicule en couleurs, et m'en avait donné toute une provision, ainsi qu'une caméra, pour voir ce que je pourrais faire. » (Facebook.com, 2020).

was a short film named “La Garoupe”, more than 10’ long, some portions of which were recently shown in a French documentary named “Un été à la Garoupe” (Lévy-Kuentz, 2020).

With multilayered emulsion of monopacks the competition was also tough. In 1936, the I.G. Farbenindustrie A.G. at Wolfen in Germany managed to develop a technology of anchoring color couplers to individual emulsion layers, by the use of molecules with a long-chain structure. This way a process of selective color development by controlled diffusion was no longer necessary. The color couplers could be incorporated into the monopack film, and not during the developing process of the exposed film. Finally, after a satisfying selection of couplers for each of the three layers, Agfa introduced in October 1936 the Agfacolor Neu film including a multi-layer reversal technology (Flueckiger, 2012).

The necessary simplification of the three-color Kodachrome developing process

For Eastman Kodak, the elegant solution of the Agfacolor Neu was a technological and economical threat even if the colour rendering of the Kodachrome film was slightly better. The technology used by Agfa was far simpler and rendered the 28 steps necessary to the processing of Kodachrome films obsolete. Kodak’s first action was to develop a simpler processing for the Kodachrome films. It was not before 1938 that they released this new processing. The controlled diffusion bleach was replaced with selective re-exposure for each colour-development step. In this way the total number of steps was reduced to 18 (Eastman Kodak Co., 1989, p.52).

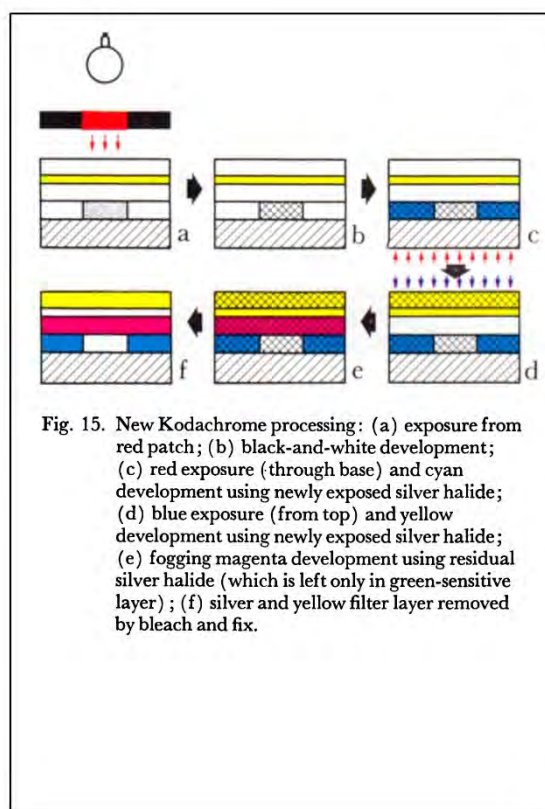
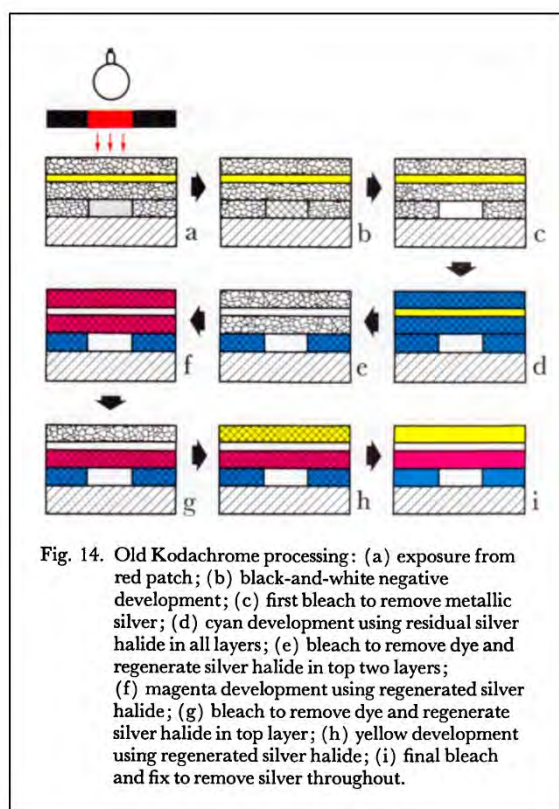


Fig. 3. First Kodachrome developing process (1935-1938) compared with new Kodachrome developing process (from 1938) in Weissberger (1970).

Lot Spaulding Wilder, a researcher of the Rochester Laboratory, was the inventor of the Kodachrome processing simplification.³ After the release of the Kodachrome monopack, Mees decided to create

³ For the record, Lot Wilder was also the grandfather of my PhD supervisor Kelley Wilder at De Montfort University.

an experimental department for colour photography including Wilder, Ralph M. Evans and Wesley T. Hanson. Mannes and Godowsky also played an important role for scientific and patent work during the period up to the outbreak of the Second World War.

The final process was described by Friedman (1944, p.122). The new processing was equivalent up to the exposition with red light and the development in cyan developer (Fig. 3). The move from theory to production was unsurprisingly tough (Mees, 1944, p.234).

Conclusion

We have seen that the introduction of the 16mm version of Kodachrome in 1935 was only the beginning of Kodak research on color technology. But it was only made possible with the long-term collaborative work with the atypical photochemists Mannes and Godowsky and the researchers of the Kodak Research Laboratories. Mannes ceased his collaboration with Eastman Kodak in 1939. The same year, Godowsky left the Kodak Research Laboratory but still worked on colour photography as a consultant in a small personal laboratory in Westport, Connecticut, nicknamed “Kodak Park Westport”. After the second World War, the knowledge produced and mastered on color technology would lead to other Kodak processes, such as Kodacolor negative film, Ektachrome reversal film and Eastman Color Negative.

Bibliography

Anon. (1935) ‘Home Color Movies May Be Made without Camera Filters’, *The Science News-Letter*, 27(732), p. 246.

Brayer, E. (1996) *George Eastman: A Biography*. Baltimore: Johns Hopkins University Press.

Coe, B. (1978) *Colour Photography: The First Hundred Years, 1840-1940*. London: Ash & Grant.

Collins, D. (1990) *The Story of Kodak*. New York: H.N. Abrams.

Coote, J. H. (1993) *The Illustrated History of Colour Photography*. Surbiton: Fountain.

Eastman Kodak Company, (1971) *Kodak Milestones*. Rochester : Eastman Kodak Company, pp. 12-13.

Eastman Kodak Company, (1989) *Journey: 75 Years of Kodak Research*. Rochester, N.Y.: Eastman Kodak.

Facebook.com, (2020) *Le Cinéma du Musée | Man Ray - La Garoupe (1937) | Centre Pompidou*. Available at: <https://fb.watch/5nqIV0iC9N> (Accessed: 12 February 2021).

Flueckiger, B. (2012 ff.) *Timeline of Historical Film Colors*. Available at: <https://filmcolors.org/timeline-entry/1276>. (Accessed: 15 February 2021).

Friedman, J. S. (1944) *History of Color Photography*. Boston: American Photographic Publishing Company.

George Eastman House, Inc., (1964) ‘Leopold Mannes, 1899-1964’, *Image*, 12(4), pp. 15-16.

James, T. H. (1990) *A Biography-Autobiography of Charles Edward Kenneth Mees, Pioneer of Industrial Research*. Rochester, N.Y.: Photographic Research Laboratories, Eastman Kodak Company.

Lévy-Kuentz, F. (2020) *Un Été à La Garoupe*. Documentary.

Mees, K. (1944) 'Direct Processes for Making Photographic Prints in Color', *Journal of the Society of Motion Picture Engineers*, 42(4), p. 234.

Mannes, L. D. and Godowsky, Jr., L. (1924) 'Color photography.'. Patent 1,516,824, United States of America.

Mannes, L. D. and Godowsky, Jr., L. (1925) 'Color photography.'. Patent 1,538,996, United States of America.

Mannes, L. D. and Godowsky, Jr., L. (1938) 'Color photography.'. Patent 2,113,329A, United States of America.

McCarthy, J. B. (1987) 'The Two-Color Kodachrome Collection at the George Eastman House', *Image*, 30(1), pp. 1-12.

Pacary, C. (2020) '« Un été à la Garoupe » : dans l'intimité surréaliste de Pablo Picasso, Dora Maar et leurs amis', *Le Monde*. Available at: https://www.lemonde.fr/culture/article/2020/11/28/un-ete-a-la-garoupe-dans-l-intimite-surrealiste-de-pablo-picasso-dora-maar-et-leurs-amis_6061512_3246.html (Accessed: 15 February 2021).

Pénichon, S. (2013) *Twentieth Century Colour Photographs. The Complete Guide to Processes, Identification & Preservation*. London, Los Angeles: Thames & Hudson.

Phillips F. B. (1935) '1934/35'. London.

Sipley, L. W. (1951) *A Half Century of Color*. New York : Macmillan Company.

Weissberger, A. (1970) 'A Chemist's View of Color Photography: How Does Color Photography Work? What is Required of the Light-Sensitive Material? What is the Origin of the Image Dyes?', *American Scientist*, 58(6), p. 651.

Spliced, face-mounted inkjet print – one preservation solution for large format photographic artworks

Markus Paul Müller¹, Ute Henniges²

¹Berlin Recom Art

²Stuttgart Academy of Art and Design, Conservation of Works of Art on Paper,
Archives and Library Materials

Contact: Markus Paul Müller, mmueller@berlin.recom-art.com

Abstract

This paper reports technical opportunities to improve the permanence of spliced face-mounted photographs addressing both the stability of the print itself and the splice seam. Among other results, accelerated ageing with heat and humidity, shows that inkjet papers have superior color stability and that pigments used for retouching remain stable for a longer time than dye-based retouching colors. Based on these findings, an optimized production process is described that illustrates the potential of technical solutions for improved long-term stability of large-scale contemporary photography.

Keywords: inkjet, face-mounted, splice, pigments, permanence.

Introduction

Typically, large-format contemporary photography takes the form of a spliced print which is adhered to a mount with silicone and then placed behind an acrylic protection. Unfortunately, some of the artworks produced with this technique are in poor state of conservation usually due to one or both of the following reasons: the desired durability falters due to unacceptable color changes or the acrylic protection has not been able to withstand mechanical damage (Murphy 2007).

Zorn and Dobrusskin (2011) and Blaschke-Walther and Dobrusskin (2015) investigated the light sensitivity of face-mounted prints. They studied the influence of the material combinations on the light stability of face-mounted color photographs. They found that yellow was the least stable color with the highest sensitivity to light. The yellow dye showed the biggest decrease in density irrespective of the different substrates or color mixtures.

The challenges of face-mounted prints are known and well-studied and have resulted in strict exhibition policies and recommendations for dark and cool storage to slow down color degradation due to temperature and fading caused by light (Daffner 2003, Fischer 2019). However, constraints arising from the complex composite structure of mounted prints and the steps involved in the sophisticated technical production process are understudied.

As it stands, the photographic print and its acrylic protection form an inseparable unit. Damage to one of the components affects the entire artwork with few chances of remedy. Obviously, the technical nature of this composite and the fact that a variety of industrially produced materials need to be combined in a skillful way are unable to be addressed by preservation approaches after the fact and often implications occurring within this production process, stemming from the variety of materials used, go without notice. Therefore, improvements can only be achieved in a sustainable way if careful preservation strategies go hand in hand with a critical discussion of the production methods and changes therein. Improvements in the production process should be both, technically feasible and commercially available.

Since many large format prints cannot be produced on one piece of paper, splicing of the individual pieces is needed. To achieve perfect aesthetics in the spliced area, retouching is needed. Common problems with retouching relate to the colors typically used and their combination with mounting silicone. In addition, spliced papers suffer from the following challenge: The seam of the two individual paper sheets must be close-fitting so that no line is visible that would disturb the image and distract the eye. However, this tight seam can cause small air pockets to form, making small light-colored fluid inclusions visible. Previously, the small gap between the two papers was filled with tinted wax making use of its soft and moldable texture. This approach brought about good results, but only temporarily. Unfortunately, the dye molecules of the tinted wax migrate over the years. This is especially the case with cyan and blue dyes which showed a tendency to move away from the seam due to adhesion forces. It is believed that the dyes can migrate easily through the silicone layer.

In this paper we would like to report technical opportunities for improved permanence of spliced face-mounted photographs addressing the stability of the print and the splice seam.

Results – accelerated ageing

We tested a selection of materials with promising features including pressure sensitive mounting film, silicone, pretreated acrylic glass, pigment printed inkjet paper, and retouching inks. Aside from testing individual materials, selected combinations thereof were also submitted to accelerated light (50°C, no humidity control; light intensity @ 420 nm: 1.10 W/m; UV filter windows Q, cut-off 310 nm, 240 hours) and climate ageing (80°C and 65% relative humidity in closed vessels, six weeks). An Oddy test set-up supplemented the research (for technical details: Korenberg et al. 2018). The visual perception was supported by spectrometric parameters, i.e., comparing initial color values on a specified test panel to the ones after different ageing protocols (fig. 1).

In short, our main findings after accelerated aging experiments are as follows:

- The results corroborate the protective effect of face-mounting with acrylics for colors observed in previous studies.
- The Oddy test points towards potential off gassing from the chromogenic papers included in this study. Inkjet and C-prints release substances that change the metallic indicators used in the Oddy test.
- Inkjet papers show superior color stability in hot and humid climates.
- All commercially available pressure sensitive mounting films and tapes cause yellowing of the mounted samples irrespective of the source of the C-print paper support. Inkjet paper is less sensitive towards reactions with pressure sensitive mounting films and tapes.
- Artificial aging showed that the pigments used for retouching remain stable for a longer time than dye-based retouching colors.



Fig. 1 – Left image: C-print (Kodak Endura Premier N), Right image: Inkjet (Hahnemühle Photo Rag Baryta). From left to right: Light ageing, no ageing, hot and humid ageing.

Results part - Improved Production

Based on observations from every-day life and from our accelerated ageing experiments in addition to recommendations from dye manufacturing experts, pigments replace dyes in our improved production process. For the inkjet print, Hahnemühle Photo Rag Baryta 315g/m² is used as paper support and the image is printed with Epson UltraChrome Pro inks. This combination of materials constitutes the standard in art production. From an aesthetic perspective, replacing the chromogenic print with inkjet printing also requires the simulation of the particular color space and color aesthetics specific to chromogenic prints within the inkjet medium. This simulation can take place by means of appropriate device links in the digital image preparation. For retouching the seam, Aero Color Professional pigmented inks from Schmincke are used and tested. These inks can be diluted with water to achieve delicate tones.

The two halves of the image are overlapped and cut simultaneously with a special blade. The blade must be as thin as possible and at the same time rigid and strong so that the cut is clean and straight, without wobble. The finer the cut, the less visible the seam. The challenge with Inkjet paper is that the support paper is dense and thick; it consists of rag fibers which quickly blunt the blades and could potentially result in the undesirable effect of tearing rather than cutting. At the same time, the paper must not be squeezed and deformed at the seam. Due to the thickness of the paper support, the edge of the cut must be fully dyed to match over the entire length (Fig. 2). As already mentioned, retouching is done with pigments because the color fastness of UltraChrome Plus inks and our retouching inks match. It also prevents the aforementioned problem of dye migration from the seam.



Fig. 2 – Retouching the splice seam. Left image: side view. Right image: top view.

The two parts of the image are taped on the reverse side. The adhesive tape must not react on the composite of inkjet paper, retouching ink, and silicone. The thickness of the adhesive tape must be as thin as possible and at the same time show a high stability. If the adhesive tape is too thick, marks will appear on the front of the image. The seam is retouched for fit after the tape has been applied. The assembled print is laminated onto the acrylic plate with the help of a steel roller in the appropriate width at a constant pressure. The transparency of the silicone and its thickness are decisive in determining whether dark areas in the motif are lightened due to the opacity of the silicone. The process must take place quickly, as the ink-receiving layer causes the silicone to dry more quickly. In the case of incorrect processing, so-called "snowflakes" can form between the acrylic glass and the inkjet print. These "snowflakes" are caused by partial and too fast setting of the silicone. The ink-receiving layer has the unfortunate propensity of quickly drawing moisture into the interior of the paper. This characteristic poses a big challenge to the process. After drying, the seam should not have any white areas in a close-up and the tape should not be visible in the form of light lines. The retouched seam is visible when viewed close up, but it should be retouched in such a way that the image - at the appropriate distance - is not visually disturbed (fig. 3).

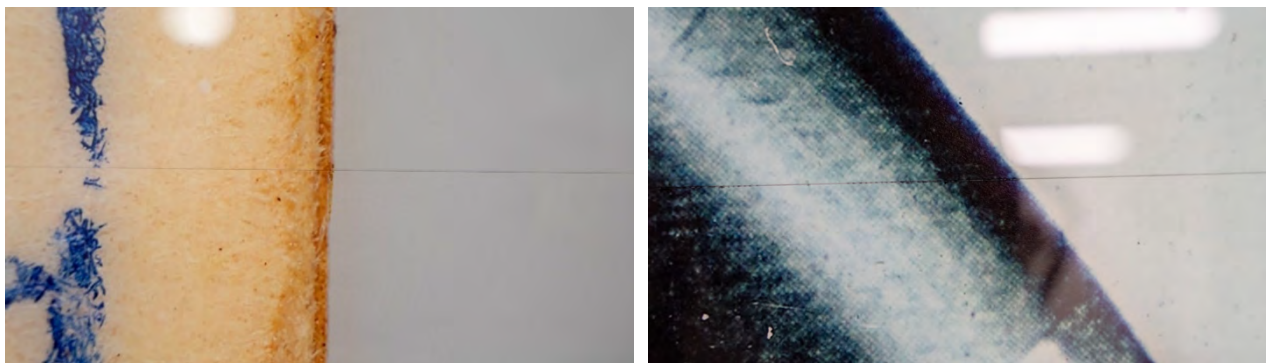


Fig. 3 – Final view of the spliced face-mounted print. Left image: light print area; Right image: dark print area.

Conclusion

Through close cooperation between science, industry, and processing service providers, technical improvements and commercial viability are feasible, while at the same time maintaining aesthetic quality and conservation requirements. We may state that the superior quality of pigment-based inks overcomes the tendency of color fading typically encountered with dyes. Also, the material combination of inkjet paper, silicon and acrylic glass tested in this study show an increased resistance towards optical disturbances caused by the undesired interaction between the materials used. Improved mechanical properties are achieved by implementing a scratch-resistant acrylic protection.

Acknowledgements:

We would like to thank Franziska Leidig and Irene Brückle from the Stuttgart Academy of Art and Design, Silvia Pawellek and Anja Spitzer, both Neschen Coating GmbH, the Team at BERLIN RECOM ART, Christopher Prasuhn, and Michael Mastalerek for their valuable contributions and dedicated work.

Bibliography

Blaschke-Walther, K. and Dobrusskin, S. (2015) 'Unmounted Versus Face-Mounted Inkjet Prints Analyses Concerning Their Light Ageing Behaviour', *Journal of Paper Conservation*, 16(1), pp. 9-17. DOI: 10.1179/1868086015Z.00000000001.

Daffner, L. A. (2003) 'Survey of Cool and Cold Storage Facilities for Fine Art Photograph collections', *Topics in Photographic Preservation*, 10, pp. 151-161.

Fischer, M. (2019) 'Creating Long-Lasting Inkjet Prints', Northeast Document Conservation Center.

Korenberg, C. et al. (2018) 'Refinements Introduced in the Oddy Test Methodology', *Studies in Conservation*, 63(1), pp. 2-12. DOI:10.1080/00393630.2017.1362177.

Murphy, E. (2007) 'Basic Care of Face-Mounted Photographs at The Museum of Modern Art', *Topics in Photographic Preservation*, 12, pp. 160-174.

Zorn, S. and Dobrusskin, S. (2011) 'DiaSec and other other finishing techniques', *Studies in Conservation*, 56, pp. 257-266. DOI: 10.1179/204705811X13159282692842.

MOUNTING CHROMOGENIC PRINTS – one potential solution for the prevention of yellowing issues on photopaper

Markus Paul Müller¹, Ute Henniges²

¹Berlin Recom Art

²Stuttgart Academy of Art and Design, Conservation of Works of Art on Paper,
Archives and Library Materials

Contact: Markus Paul Müller, mmueller@berlin.recom-art.com

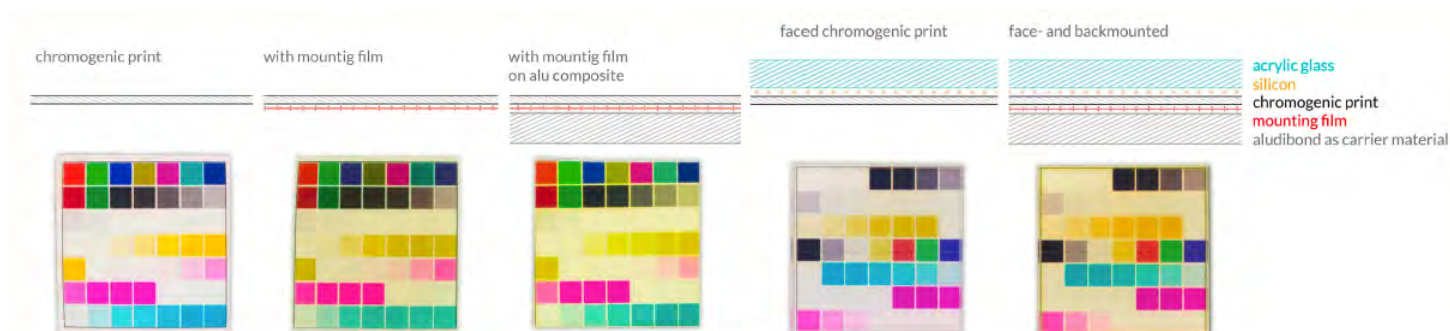
Abstract

Through evaluating changes in the spectrophotometric colour measurements taken before and after exposure to hot and humid conditions, we were able to identify that the pressure sensitive mounting film is one of the primary causes for yellowing of mounted chromogenic prints. Based on these findings, an improved mounting system seemed to be the most promising approach, since eliminating one source of yellowing, especially at the beginning of the production stage supports long-term preservation strategies. With the introduction of a new adhesive formula, but otherwise identical sample material, we replicated the experiment and demonstrated the improved color stability which could be garnered through this approach.

Keywords: adhesive mounting film, yellowing, discoloration, aging tests, solution, preservation strategy

Introduction

Light exposure and inadequate storage conditions have long been considered the primary factors contributing to undesired color changes in chromogenic prints; with the secondary culprit being the inherent instability of the chemicals used in the dyes. With the aim of illuminating the impact of the variables within the production itself, which potentially contribute to the yellowing of chromogenic prints, the individual materials used within typical productions were submitted to a hot and humid aging protocol in closed vessels (28 days, 80°C, 65% relative humidity). Herein, we would like to focus on the visual results from the hot and humid aging protocol.



(Fig. 1) Direct comparison of chromogenic prints after hot and humid aging in different mounting situations. From left to right: without mounting; with mounting film; with mounting film on aluminum composite; face-mounted; face and backmounted. While face-mounting protects the chromogenic print (second from the right), all other mounting scenarios cause yellowing under the tested conditions.

Individual Paper Tests vs Combination with Laminating Materials

When we exposed the individual photographic papers to our heat test there were no observable yellow discolourations. We then subsequently tested the variations of material combinations (see Figure 1).

Contrary to the first test where only the individual papers were tested, the various combinations which included the laminating materials developed dramatic yellowing. Thus, it became evident that this yellowing of chromogenic photo prints originates, among other factors, from the double-sided pressure sensitive film that is used for mounting.

Testing Various Mounting Films

In a second phase of the project, a large variety of internationally available double-sided pressure sensitive films for lamination of chromogenic prints were subjected to the previously established color measurements and aging conditions. The same type of discoloration occurred in all tested materials, indicating that none of the commercially available material combinations applicable in the context of professional production for lamination of chromogenic prints were recommendable for long-term use.

Collaboration Between Industry and Producers

To improve the color permanence of chromogenic prints, recom ART GmbH & Co. KG decided to collaborate with Neschen Coating GmbH, a manufacturer of adhesive films, to develop a new material for lamination. Tests were then carried out on identical sample material (Kodak Endura Premier N) with the same measurement and aging methods previously established in our experiments (80°C and 65% relative humidity) which ensured accurate comparability with our previous findings. The focus of this ongoing research is to develop a product which both performs reliably and has minimal chemical reaction with the photo papers. Notably, our preliminary results of lab-scale tests using this new adhesive film, show a decrease in the yellowing tendency. (see Figure 2).



(Fig 2). Direct comparison of printing papers after hot and humid aging. Left: mounted on aluminum composite with standard adhesive; middle: printing paper not mounted, right: mounted on aluminum composite with new adhesive formulation (numbers on the samples refer to internal numbering for sample identification).

Conclusion

Through close cooperation between science, industry, and processing service providers, we believe that technical improvements and commercial viability are feasible, while at the same time maintaining high aesthetic quality and conservation requirements.

Acknowledgements

We would like to thank Franziska Leidig and Irene Brückle from the Stuttgart Academy of Art and Design, Silvia Pawellek and Anja Spitzer from Neschen Coating GmbH, the Team at BERLIN RECOM ART, Christopher Prasuhn and Dipl.Ing. Michael Mastalerek.

DIGITIZATION OF LARGE-SCALE ARTWORK WITH LED TECHNOLOGY

Markus Paul Müller¹, Raffael Pollak²

¹Berlin Recom Art

²Dedo Weigert Film GmbH

Contact: Markus Paul Müller, mmueller@berlin.recom-art.com

Abstract

Currently there is no common practice for digitization of large-scale artworks on site. The team of Dedolight and recom ART wants to engage in a scientific exchange to establish a modular system that can be used onsite in museums, storage rooms and other places to digitize color accurately and which can handle large-scale art works with sizes up to 3 x 6 meters. By developing special instruments for shaping the light, surfaces on walls will be illuminated homogeneously while keeping the workspace and all other artworks in the room safe from the pollution of stray light. In addition, the system will be a fully integrated calibrated solution.

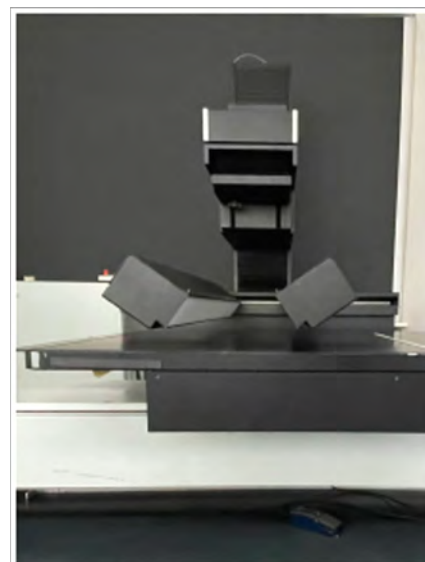
Keywords: digitization, LED technology, large-scale artworks, on-site digitization

Introduction

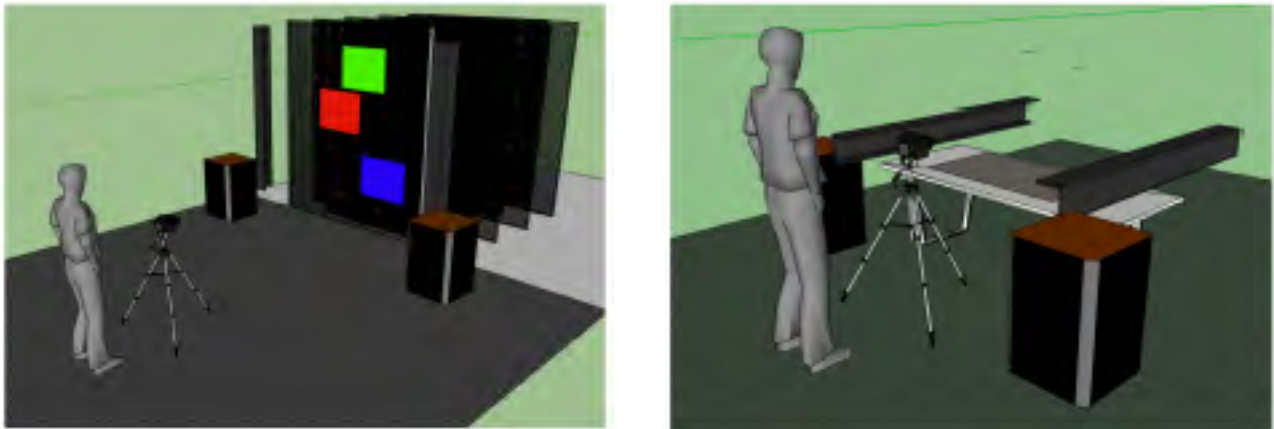
The latest developments in precision optics and light sources with adjustable color temperatures, have led to a joint venture between Dedo Weigert Film, Munich and recom ART, Berlin, where each party contributes their core expertise: precision lighting instruments and accurate art reproduction. The team wants to develop an integrated calibrated solution in close exchange with users. Until now digitization has been done in studios off site, in the museum workshops or via external suppliers. To be faster, more precise, less harmful to the artwork and possibly also cheaper in the overall costs, the team wants to introduce a portable, yet calibrated system which can keep up with the demands of the art world. The final result will be digitization which is accurate, conclusive, and exact. The color values of the original will be measured as $L^*a^*b^*$ color values with the appropriate technology and correspond to the displayed color values of the file. This technical principle comes from the reference scan of recom ART, who have been actively developing accurate color digitization. The high-quality LEDs and their precise color rendering enable the light to be precisely profiled for the respective camera and is open to all types of camera systems.

New Solutions

While the current systems available for large scale digitisation are effective and produce exemplary results, they do have limits which could be improved upon and digitization situations which require new solutions. The current Cruse Scanner system (see Figure 1) is a stationary scanner which is typically used in-house at recom ART GmbH & Co. KG, and necessitates that the artwork be transported to the site of scanning. Otherwise, in rare instances when chosen to be used on-site, without moving the artwork, the transportation and setting costs are very high. With these limitations in mind, we set out to create a new workflow which would be flexible and easy to move, without size limit, have the option of a table version, as well as have the ability for set up within exhibition halls and storage spaces.



(Fig 1) Cruse Scanner at recom art, GmbH & Co. KG



(Fig 2) Setup for horizontal digitization in storages and exhibition rooms and vertical digitization in labs for artworks on paper

Asymmetrical Reproduction Lighting

A custom LED formation can produce specific color temperatures to digitize photographic works and view them under lighting conditions similar to the final presentation. Custom asymmetric reflectors would combine even-illumination while minimizing light pollution of the work space. This standardized light and coordination of all components, would enable color-correct digitization of large format artworks without the need for subsequent processing. Due to our already existing mobile and standardized technical structure there would be ease of access to digitization on site. Accurate surface images can be achieved through controllable light situations and directions. The single image files can be used for conservation related reports. The homogeneous illumination allows for a gentler digitization than previous methods. A system incorporating specialized optics, multi-spectral image capture and an intelligent algorithm for driving and dimming the LEDs minimizes the exposure dose drastically.

Color Management and Profiling

The planned workflow will enable the respective camera-lens-lighting setup to be clearly defined and corrected using these profiles to define a standard. The same quality and conditions of digitization can be achieved among different shooting locations thus resulting in a simplified production process. Applications for this workflow are endless, for example in catalog printing and condition reports, and specific to photography, the need for accurate color digitization is crucial in the preservation strategy of so-called “reprinting” of contemporary photographs.

Conclusion

The presented project is in its initial phase and would like to invite interested institutions and specialist groups to take part in the challenge. In the first phase, perfected wall lighting will be developed to allow practical work and documentation on large-scale pieces. In a research project, the effects of LED lights are to be researched and existing studies need to be validated. The intended focus will also include the practical handling and feasibility of using these lights. Additional crucial questions such as the effect of the Pulse-width modulation dimming frequency and the harmful components in the color spectrum, such as the blue pump peak. The experience of artists, conservators, curators and practitioners of light and digitization technology will also be drawn upon in different test phases and will be incorporated into the final product.

REFERENCE SCAN AN OBJECTIVE WAY TO DOCUMENT COLORS AND SURFACE CHANGES IN ARTWORKS

Markus Paul Müller¹, Sven Schönaauer¹

¹Berlin Recom Art

Contact: Markus Paul Müller, mmueller@berlin.recom-art.com

Sven Schönaauer, sschoenauer@berlin.recom-art.de

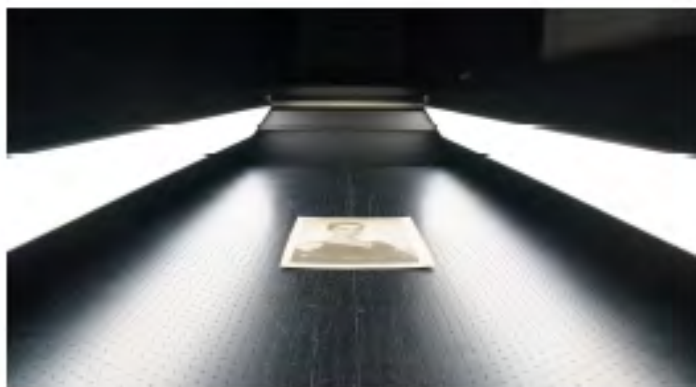
Abstract

The reference scan is a digitization of finished works of art which shows correct color values of the original as well as depicting typical characteristics of the production process such as retouched areas. The color values recorded in the file correspond to the measurable color values of the original work of art. Specific to photography, future conservation strategies would be aided by scanning the final piece directly after production and including color values and motif information within the document. If the photographs need to be reprinted, the reference scan would then offer objective information about the color at the time of digitization.

Keywords: reference scan, digitization, digital copy, color values, reprinting, damage mapping

Introduction

The reference scan workflow consists of specific conditions which all contribute to as accurate a reproduction as possible. The first aspect is the color management of the scanner and involves a special target which allows for the optimization of the full color range, resulting in the colors within the file being shown without any interpretation. The second feature is using a lighting setup which has a full range for controlling the direction of the shadows cast – we can reproduce scans without any shadows as well as scan the full structure of the surface using focused light. A valuable application of the latter is the documentation of changes to the surfaces of artworks, especially within the context of preservation. Once the scan has been made, we measure L*a*b* color values of the original which are then entered into the digital file and used to correspond and edit the displayed color values. The purpose of creating such a digital copy is for use as a digital reference documenting the exact characteristics of the piece at the time of digitization which can then be used to check any color changes of the original over time as well as assist in subsequent reproductions.



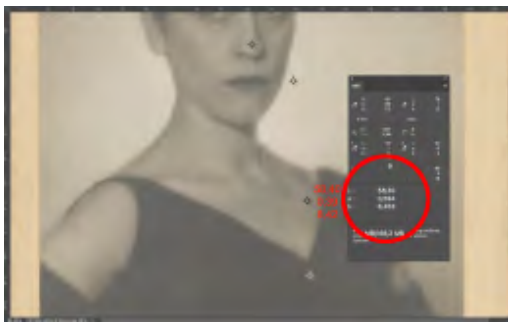
(Fig 1) Scanning the original with our Cruse Scanner



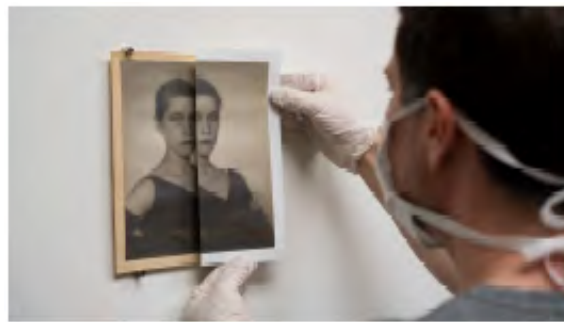
(Fig 2) Spectral measuring the original)

Use of Color Values

Using a spectrophotometer, color values of the original piece are taken at specific points. The base measurements always include the white and black point with additional points for main color or steps of grey within the piece added if necessary. Also taken into consideration are properties which may influence the measurement such as coatings, optical brighteners, structures, open surfaces, and degree of gloss, among others. Through comparison of the inherent color values within the scan data and the outside measurements taken from the piece, we are able to determine tolerances and make fine-tuned adjustments to compensate if necessary. Furthermore, these values may then be used as the basis for reproduction and if for instance in the case of photo reproductions, where the original material and reproduction materials are the same, then the respective $L^*a^*b^*$ values of the digital reference can be measured against.



(Fig 3) Checking the digital color values comparing to the measured color values



(Fig 4) The reference scan helps to reprint the original and gives objective information about color gradation and density.

Damage Mapping

An important application for digital references of artworks are their use within condition reports. Thanks to the distortion free digitization, imperfections such as scratches, discoloration, or other irregularities both on the surface of the print but also within its structure such as in the case of a painting on canvas, can be recorded in original size and used to keep an eye on any further spreading or additional damage which may occur subsequently. This can easily be done both through comparison to the original but also through comparison to additional scans which can show details which the eye may not see.

Conclusion

Since 2005 the reference scan has been used by recom ART for digitization of any kind of flat artwork. For example we use the reference scan for the auction house Grisebach in Berlin. The files are used for their advertising, auction catalogue as well as to show the state of individual pieces at the time of sale during their communication with clients. Additionally, a new and significant conservation strategy within contemporary photography is the practice of scanning the finished artworks directly after they are produced so as to document accurate color reference. Since the Cruse Scanner, which we use for the reference scan, is limited in its handling of larger sizes, we are required to scan large artworks in parts and then stitch them together in post edit. As presented in our poster „Digitization of large scale artwork with LED technology“ we are working together with Dedo Weigert Film, Dedolight, Munich on a new way to digitize large scale artwork.

eTDP - EXTENDED TECHNICAL DOCUMENTATION OF PHOTOGRAPHY

Markus Paul Müller^{1,3}, Jessica Morhard^{2,3}

¹Berlin Recom Art

²Folkwang Museum, Zentrum für Fotografie Essen

³Member von Deutsche Gesellschaft für Photographie e.V (DGPh)

Contact: Markus Paul Müller, mmueller@berlin.recom-art.com

Abstract

Under the umbrella of the German Photography Society (DGPh) the working group “Conservation of Contemporary Photography” was formed. Our members include restorers, photo lab technicians, scientists and representatives of the photo industry (see Figure 1). The purpose of our working group is to develop solutions and recommendations for the preservation of contemporary photography

Keywords: Extended Technical Documentation of Photography, eTDP, working group, Index of Changes in Contemporary Photographs, experts, documentation

Introduction

Due to delicate materials and unexplored material interactions, contemporary photographs are often subject to rapid changes in condition as well as deterioration from mechanical damage. As a conservation methodology, damaged photographic artworks are reproduced or exhibition copies are made. However, for authentic reproduction, information is usually lacking and objective comparison to the original condition can often not be completed. Although there are helpful tools for conservation, such as the Photographic Information Record, there is a lack of acceptance and inadequate implementation of the form in Germany. Decisive criteria that enables an objective assessment of the change in condition, such as LAB-color-values made immediately after production, are not taken into account, and valuable information on material and production is imprecisely documented. The working group was created in order to fill this substantial gap, as well as contribute to the overall discourse addressing the subject of reprinting.

First Task: eTDP

It was decided that the initial focus of this working group would be the development of an extended Technical Documentation of Photography (eTDP), which would include information on technical aspects of image output as well as color documentation. By including new features such as drop down menus with attached thesauruses of terms within an app format our hope is that future documentation would be easy to complete and standardized so that it could be done by both producers and the artists themselves. In addition, the app would be accessible to a specific set of people on a web-based database. Furthermore, in order to strengthen the



(Fig 1) First workgroup meeting at the DZ Bank Kunstsammlung Frankfurt, 06.03.2020.

acceptance and broad support of all stakeholders of this topic, which is necessary for its success, the working group is conducting discussions with high-profile experts and is opening itself up to public dialog by providing a comment function (see Figure 2).



(Fig 2) Screenshot from the working group website etdp.de



(Fig 3) Index of Changes on Contemporary Photography, a fillable pdf-form, the figure shows page 1

Specialized Training

Additionally, through our intensive examination of the topic, further tools have been developed that will contribute to the preservation of contemporary photographs. This occupation requires proficiency in the handling of the often fragile objects, as well as up to date knowledge in the ever-advancing material and processing technology of image production. In order to strengthen the skills of conservators, the working group, together with the Institute for Conservation Sciences at the State Academy of Fine Arts in Stuttgart, is developing a specialized training program and thus actively contributing to expanding the expertise around this topic.

Index of Changes in Contemporary Photographs

As a further tool, the working group is developing the Index of Changes in Contemporary Photographs. The index records changes in condition and production-related phenomena in contemporary photographs. It consists of a two-page fillable pdf-form (see Figure 3), in which an observed phenomenon is described, possible causes are named and avoidance strategies are indicated. The collected documents are made available through the website and serve as a reference tool. At best, interested readers can use the information gained from the index to avoid undesirable changes in the condition of contemporary photographs before they happen.

Conclusion

Through these projects the working group has already been able to sensitize and alert responsible parties –for example producers and artists– to these challenges and inefficiencies within the field. Our project has contributed to further acceptance and understanding of the specific needs of contemporary photography as well as possible prevention methods. We would like to end with an invitation to all interested parties to participate in the working group, which can be done through contributing to the index or by joining our working meetings which are currently happening digitally.

Conservation treatments for Autochrome plates: limits and possibilities

Sara Brancato¹

¹Complutense University of Madrid

Contact: Sara Brancato, sa.brancato@gmail.com

Abstract

In this article we will talk about the first color plate that completely revolutionized the photographic industry and changed the way of recording reality, no longer in black and white: the autochrome plate of Lumière brothers.

We will distinguish fabrication faults and deterioration that can be affected this kind of color photographs, with the aim to illustrate the limits and possibilities of restoration treatments.

Keywords: autochrome, Lumière brothers, photography, restoration, treatments.

Introduction

The birth of photography has been a true revolution that has brought profound changes in our way of seeing the world, of understanding it and documenting it. Since its inception, it has been his desire to try to faithfully record what is observed, with clarity and nuances, which has led many personalities to investigate with determination the ways of reproducing color.

These first studies resulted in techniques that are difficult to execute by non-professionals, leaving the obtaining of color images reserved for a few experts. However, in 1907 everything changed: the Lumière brothers commercialized the first plates with which to take color photographs, the so-called "Autochrome Lumière", which, due to their ease of processing, reached a rapid diffusion, not only among photographers professional but also among "amateurs".

Although it is the first color process that had an industrial system for its manufacture, it could also involve an artisan component that, on the other hand, undoubtedly influences its conservation and restoration and will mark the line between what we can do or not.

The fabrication of autochrome plates and its faults

The Lumière brothers had finally succeeded in creating a type of photography which not only enabled the recording of reality in color, but which could also benefit from an industrial production system, which allowed its wide diffusion.

The fascination of autochrome plates also resides in their particular structure, which gives the final image a "pictorial" finish, highly appreciated already at the time of its creation (Fig. 1).



Fig. 1 –Detail of the autochrome plate in transmitted light. Spring 1915 [daffodils]. Author's photograph collection.

The autochrome plate is a succession of layers that allows the formation of a color image: a glass support, a first varnish made with latex and dammar dissolved in benzene, which receives a layer of potato starch microgranules, dyed blue-violet, red-orange and green, powdered by smoke black. This layer is followed by another layer of varnish, this time composed of dammar, ethyl acetate, castor oil and cellulose nitrate. Finally, a panchromatic gelatin emulsion finished the multi-layer structure (Fig. 2).



Fig. 2 - Structure of an Autochrome plate

The exposure was carried out by placing the plate with the glass side facing the objective, so that the colored screen filtered the light rays that they would have impressed the emulsion.

After taking the shot, which used to last 1.5 seconds in full sun, the plate was developed and, in some cases, it was varnished with dammar or another varnish, such as *Zaponlac*, composed of nitrocellulose. Varnished or not, the plate could be fitted with a cover glass, with the intention of preserving the gelatin.

Paper frames could be placed between the emulsion and the cover glass, which are very common in the plates using in teaching (Fig. 3).



Fig. 3 – Paper mat visible in reflected light. Spring 1915 [daffodils]. Author's photograph collection.

The cover glass was sealed to the autochrome with a paper tape. This could be heat-activatable or applied with a water based adhesive, and prepared in four segments.

Paper labels was used to enrich the mounting system.

The care with which this protection system was carried out had its reason in the delicacy of this object, which was taken into account since its commercialization. Due to its manufacture and processing, therefore, we find defects and marks that are specific to the technique and help us to identify the photographic process and to know its history.

We can distinguish them under different kinds of light: reflected or transmitted.

In transmitted light we can observe:

- | | |
|----------------------------|--------------------------------|
| ▪ dark spots | ▪ pale tails |
| ▪ cloud of tiny dark spots | ▪ linear bands on emulsion |
| ▪ pale spots | ▪ linear bands on color screen |
| ▪ comets | ▪ milky yellow-orange image |
| ▪ dark tails | ▪ folds in gelatin layer. |

Many elements are visible under transmitted and reflected light:

- linear bands on surface on the 2° varnish
- retouching
- paper mats.

Faults in the glass can be observed under reflected light.

On the other hand, there are defects that impair the stability of the plate and that therefore must be considered as deterioration.

These affect all the layers, even the grouped layers, and we can observe them under different lights.

In transmitted light, we can see: stains, dye fading, blocking, bleeding of dyes, leaching and the characteristic green spots, caused by the high solubility of green dyes.

Under transmitted light and reflected light, abrasions, losses, shrinkage of gelatin, cracks, for example, can be seen on the image (Fig. 4).

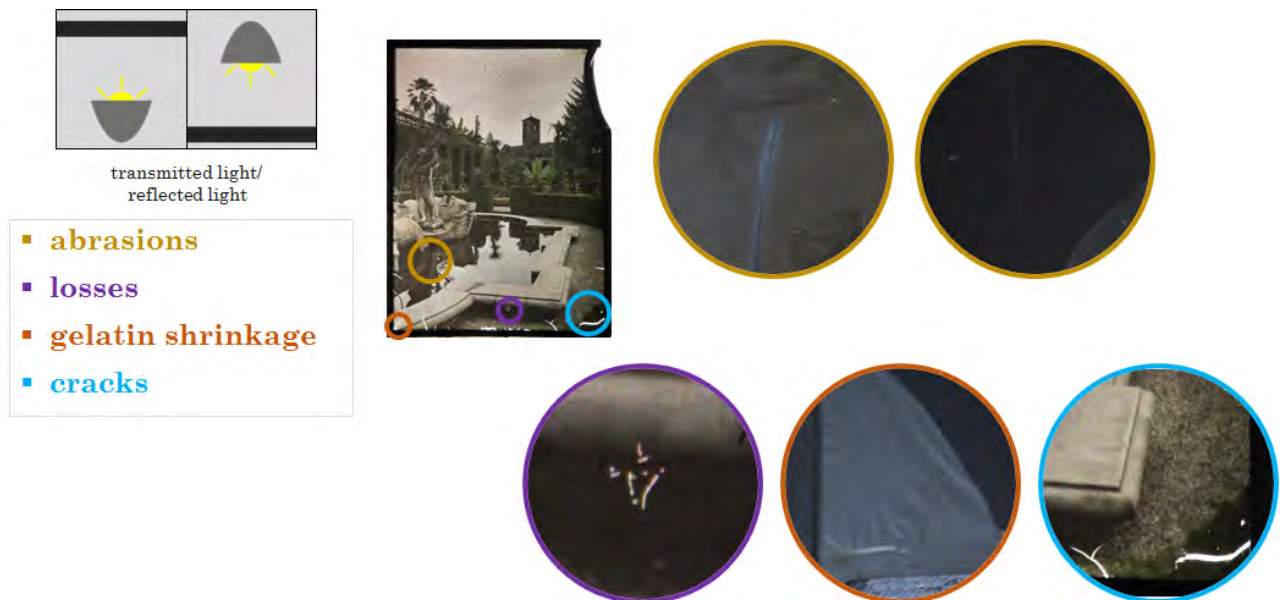


Fig. 4 – Some of the deterioration that can affect the image of autochrome plates. Author's photograph collection.

While in glass we can find cracks, breaks (Fig. 5), losses and dirt.



Fig. 5 – Some of the deterioration that can affect autochrome plates. Author's photograph collection.

In reflected light, among others, the silver mirror, delamination and dirt are observed (Lavédrine *et al.*, 2013; Casella, & Cole, 2012).

There are also cases in which the mounting system is not the original and can compromise the state of conservation of the plate, as in the case that we can see in the Figure 6.



Fig. 6– Autochrome with an improper treatment. Author's photograph collection.

The sealing made with gaffer tape is clearly visible after the breakage of the support glass and the protective glass. A label carries the information that was probably originally written directly on the strip of paper that sealed the plate, in the same way of the other plates that compose the collection to which it belongs. The breakage of the primary and secondary support is a problem that must be solved, for this same reason.

Unfortunately, we do not have all the solutions within our reach, due to the delicacy and fineness of the layers that make up the autochromes and because of the susceptibility of their layers to polar and nonpolar solvents.

For this purpose, we consider that the most ambitious treatments are the separation of the emulsion to a protective glass and the consolidation of the broken support.

On the other hand, many other treatments can be carried out quite safely:

- Surface cleaning of glass support and cover glass with solvents or soft brush.
- Surface cleaning of emulsion or final varnish layer with air bulb.
- Consolidation or delaminated layer with vapors of toluene or xylene, in order to reactivate the dammar based final varnish (Von Waldthausen & Lavédrine, 2002; Hofmann & Uwe, 2001; Muller, 2006; Passafiume, 2005).
- Replacement of original sealing tapes heat-activated or made with water-based adhesives.
- Replacement of broken original cover glass. Can be considerate to add a polyester or paper spacer (Cattaneo, 2013; Casella, & Cole, 2012) (Fig. 7).
- Adhesion of broken cover glass with epoxy resin (*Epotek® 301-2*), if it is considerate necessary (Herrera, 2014).
- Consolidation of labels.
- Adding a third glass to consolidate a broken support (Cartier-Bresson & Sirven, 2002).



Fig. 7 – Replacement of broken original cover glass and gaffer tape. From left to right: the autochrome plate during the separation of gaffer tape; cleaning of adhesive's residues; the plate with the new cover glass. Author's photograph collection.

Obviously, the reasons underlying the restoration must be weighed, and the benefits derived from the intervention must justify the risks to be assumed.

Despite being controlled and studied operations, the delicacy of autochrome plates should never be underestimated.

Conclusion

Although we still have to solve how to carry out the most ambitious treatments that we have illustrated, we have the tools to be able to determine the appropriate measures to face many of the deteriorations that frequently affect autochrome plates.

We hope that soon the growing interest in photographic heritage and, in particular, in this kind of color photography, will bear fruit and contribute to the resolution of the problems that remain to be solved.

Bibliography

Cartier-Bresson, A. & Sirven, M. (2002) “La restauration des autochromes” in Pastre, B. de, & Devos, E. (dir.), *Les couleurs du voyage. L'œuvre photographique de Jules Gervais-Courtellemont*, Paris, Paris-musées: Phileas Fogg, pp. 74-83.

Casella, L. & Cole, T. (2012) “Color Screen Processes”. In *Photographic Materials Group Wiki*. Photographic Materials Group of the American Institute for Conservation. Last edition: 24 November 2020, at 13:58. Available at: https://www.conservation-wiki.com/w/index.php?title=Color_Screen_Processes&oldid=49859 (Accessed: 11 May 2021).

Cattaneo, B. (2013). *Il restauro della fotografia: materiali fotografici e cinematografici, analogici e digitali*. Nardini.

Herrera, R. (2014) “La conservación de vidrio en fotografía. Casos prácticos: negativos en placa, autocromos y placas de linterna”, Vivancos Ramón, M. V. *et al.* (2014) *EMERGE 2014 - Jornadas de Investigación Emergente en Conservación y Restauración de Patrimonio*. Editorial Universitat

Politécnica de València. Available at: <https://riunet.upv.es/handle/10251/47276> (Accessed: 11 May 2021).

Hofmann, C. & Uwe, S. (2001) “Heinrich Kuehn and Photography with Autochromes”, *Topics in Photographic Preservation* 9, pp. 73–84.

Image Permanence Institute (no date) *Graphics Atlas: Identification, Screen Plate*. Available at: http://www.graphicsatlas.org/identification/?process_id=301 (Accessed: 11 May 2021).

Krause, P. (1985) “Preservation of Autochrome Plates in the Collection of the National Geographic Society”, *Journal of Imaging Science* 29, no. 5, pp.182–92.

Lavédrine, B., *et al.* (2013). *The Lumière autochrome: history, technology, and preservation*. Getty Conservation Institute.

Lavédrine, B. *et al.* (2010) [re]conocer y conservar las fotografías antiguas. Paris: Comité des travaux historiques et scientifiques (Colección orientaciones y métodos, 16).

Lavédrine, B. *et al.* (2003) *A Guide to the Preventive Conservation of Photograph Collections*. Los Angeles: Getty Publications.

Matè, D., & Sclocchi, M. C. (2017) *Fotografie: finitura e montaggio*. Nardini.

Muller, U. (2006). “A Method of Consolidating Delaminated Autochrome Plates from the Photograph Collection of the Albertina Museum in Vienna”, *AICCM Symposium 2006, Conservation of Paper, Books and Photographic Materials. Post-Prints and Posters*. 19-21 April 2006. Wellington, New Zealand, pp. 194–208.

Passafiume, T. (2005) “Photography in Natural Colors: Steichen and the Autochrome Process”, McCabe, C., & American Institute for Conservation of Historic and Artistic Works (Eds.). *Coatings on photographs: materials, techniques, and conservation* (1st ed). American Institute for Conservation, pp. 314-321.

Penichon, S. (2013) *Twentieth-century colour photographs: the complete guide to processes, identification & preservation*. Thames & Hudson.

Von Waldthausen, C. & Lavédrine, B. (2002) “An Investigation into a Consolidation Treatment for Flaking Autochrome Plates”, *ICOM-CC 13th Triennial Meeting*, Rio de Janeiro, September 2002, Preprints. London: James and James, pp. 22-27.

Film Reconstruction and the Forensic Imagination in The Case of “*Spedizione Franchetti nella Dancalia*”

Andrea Mariani¹, Serena Bellotti²

¹Università degli studi di Udine

²Università degli studi di Udine

Contact: Andrea Mariani, andrea.mariani@uniud.it

Serena Bellotti, bellotti.serena@spes.uniud.it

Abstract

Early on 2020, University of Udine signed a collaboration with Istituto LUCE, aimed to a digital restoration of a supposedly lost expedition film: *Spedizione Franchetti nella Dancalia* (Mario Craveri, 1929, b/w, silent). LUCE and University of Udine brought to light a large amount of film materials that included 35mm original negatives, DupPos Lavanders, Positives, and a 9.5mm reduction print but no trace of an edited version of the 35mm film. The pandemic forced the project to shift remote and forbid working on the original film materials, thus a long time was dedicated to an inspection of edge-to-edge digital scanned copy of every element: a “digital fac-simile” (Rosenthaler 2001) through continuous scanning.

While planning the philo-genetics of each digital element, as a crucial stage of *recensio* and *collatio*, on one hand we could assume that digital environment supports and sustains an “ideal allographic environment” (Goodman 1976), as to say “a premeditated material environment built and engineered to propagate an illusion of immateriality” (Kirschenbaum 2008) – a premise that helps us to legitimate any philological enterprise led on digital witnesses of analog films; on the other hand, digital technology tends to and “must produce perfect outputs from imperfect inputs, nipping small errors in the bud. This is the essence of digital technology, which restores signals to near perfection at every stage” (Kirschenbaum 2008, 133). Given this premise and the pivotal role that errors and innovations play in the stage of *recensio* and *collatio*, this proposal intends to reframe the “digital witness” by stressing the materiality of film (in digital film preservation) as an ongoing process of interpretation (rather than a given characteristics of the object), where digital philology is *always* digital hermeneutics. In fact, in this digital environment we are forced to constantly find a balance between a “Formal materiality” and a “Forensic materiality” (Kirschenbaum 2008) of film. The first refers to the evidence perceived “at the junctions” between the analog and digital states of the film, or the “differences” the restorers perceive while shifting from the state of the analog film in their mind (a state of “forensic imagination”), to the state of the film appearing in the digital witness (i.e. a digital stressed instability that correspond to a change of film element). The second pertains to the evidence of practices that impacted on the “hardware”, as to say something that is happening only in the digital object (i.e. digital artifacts produced by the digitization conditions or the technical characteristics of the digital file). To this end, we will discuss the “digital witness” characterized as a “physical object” (signs and traces inscribed in the digital medium), as a “logical object” (data extracted through the digital processes of inspection), as a “conceptual object” (the digital image as it appears on the screen), and as a physical data “storage”.

Keywords: Film restoration, expedition film, film reconstruction, philology of film.

Introduction

Early on 2020, University of Udine signed a collaboration with Istituto LUCE, aimed to a digital restoration of a supposedly lost expedition 1929 film: *Spedizione Franchetti nella Dancalia*.

LUCE and University of Udine brought to light a large amount of film materials that included 35mm original negatives, DupPos Lavanders, Positives, and a 9.5mm reduction print but no trace of an edited version of the 35mm film.

The pandemic forced the project to shift remote and forbid working on the original film materials. Therefore, a long time was dedicated to the inspection of edge-to-edge digital scanned copies of every negative reel, a “digital fac-simile” through continuous scanning (Fig. 1), particularly useful during the *recensio* and *collatio* stages of the film reconstruction.



Fig. 1 – example of the “digital witness” we are working with. On the left it is possible to read the producer’s edge mark GEVAERT and the numbers 8 and 6 from a previous generation print.

Here we call it “digital witness” and we want to highlight some aspects of it, stressing the differences perceived “at the junctions” between the analog and the digital states of the film, in the mind of the film restorer, who is dealing with a digital fac-simile of a physical print.

In the restorer’s mind operates a “forensic imagination” that constantly asks to characterize both the analogue and the digital environments of production, emerging from the digital witness of a print.

Reconstruction of the analog environment

In the forensic imagination the reconstruction of the analogue environment resonates through the appearance of the original negatives of *Spedizione Franchetti*. For example, they allow the identification and classification of different film mattes, that tell of the use of different types of cameras during the shooting.

According to these evidences, we could understand that the filmmakers used a bigger and more stable camera, with a circular matte and two others smaller cameras with a more squared matte, that produced different traces in the original negatives. Furthermore, the analysis of the order and position of the edge codes, revealed operational habits of the filmmakers, such as procedures and errors during the loading of film in the camera magazine. In fact, the film strip shot with the bigger camera, is marked by edge codes proceeding in ascending order, while the one shot with the smaller camera is

marked by edge codes proceeding in decreasing order. This was apparently due to the necessity of loading shorter rolls, blindly prepared in a sack. (Fig.2).

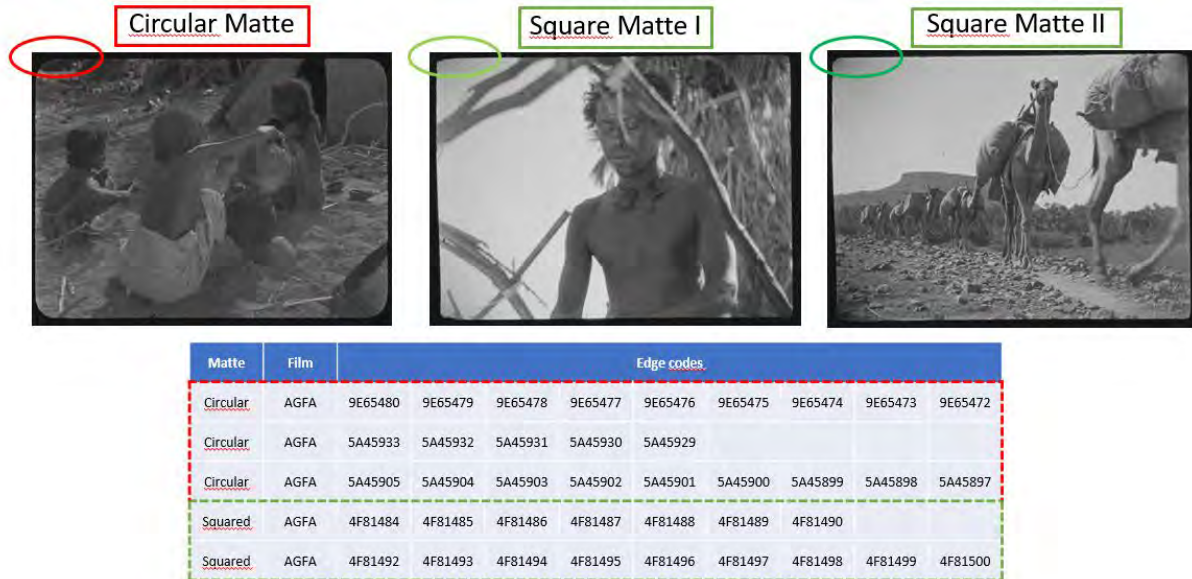


Fig. 2 – examples of the three different mattes corresponding to three different cameras used during shooting, as it is clear in the top-left corners: the first one corresponds to the more stable and squared matte from a more stable camera while the second and the third more circular are sign of two smaller cameras. The table is a section that highlight the difference between the edge codes proceeding in ascending order (corresponding to the circular matte) and in decreasing order (the squared matte)

Reconstruction of the digital environment

If the digital witness can work as a fac-simile of the analog print, it also must be considered as a different object, with its own properties that overlap with the historical errors of the physical witness. So, in the forensic imagination, the digital environment that produced the digital fac-simile must be taken into consideration too. For example, we have to consider the physical dimensions of the scanner gate and the different choices made during the scanning procedure due to the physical limitation of the film progress through the gates of the ARRI Scanner, that forced the operators to intervene on the original intertitles producing substantial alterations into the digital fac-simile we needed to take into account (Fig. 3).

But the digital fac-simile reveals properties of the digital file too, like the settings and choices made during the stabilization of the digital image, and the digital errors produced during its creation, such as multiplication of frames or glitches (Fig. 3).

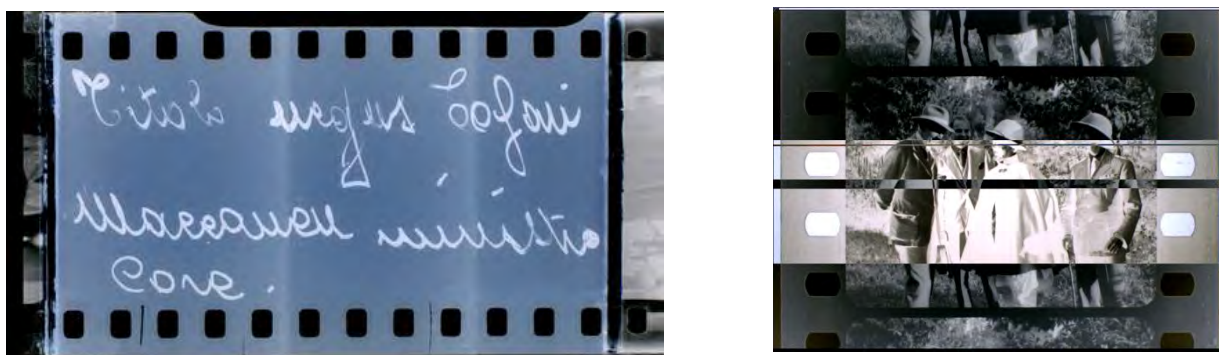


Fig. 3 – on the left, an example of an intertitle replaced for the scanning necessity. A black film reporting the original intertitle has been inserted as placeholder and then removed after the scansion operation. On the right, an example of a glitch happens during the creation of the digital witness.

Conclusion

Given the reconstructing strategy we are currently following to keep a clear picture of the innovations produced in the digital fac simile is crucial. We have no trace of an edited 35 mm version and to recreate it we started to classify and order the handwritten marks that numbered every change of scene in the digital fac-simile. Based on this comparison and classification, we could formulate hypothesis about how this films was showed in theatres and in conference presentations since we noticed that there are numbers on the left side of the print that are cyclical and that correspond to a shorter segment of film, probably serving as a narrative module for a short presentation without intertitles; on the right side, instead, we found numbers that correctly correspond to the scene sequence of the entire film, as it was probably edited with the intertitles.

To complete the picture, a strict comparison between the intertitles documented in 1937 by the *Catalogo generale dei soggetti cinematografici*, the intertitles transcript made by Istituto Luce from the original negative before the scanning, and the innovations produced in the digital fac-simile after the scanning is needed in addition to a research through the materials preserved by *Società Geografica Italiana* about that expedition.

Bibliography

Goodman, N. (1976) *Languages of art: an approach to a theory of symbols*. 2. ed., [Nachdr.]. Indianapolis, Ind.: Hackett.

Kirschenbaum, M. G. (2008) *Mechanisms: new media and the forensic imagination*. Cambridge, Mass: MIT Press.

Rosenthaler, L. (2001) 'Restoration of movie films by digital image processing', in *IEE Seminar Digital Restoration of Film and Video Archives. IEE Seminar Digital Restoration of Film and Video Archives*, London, UK: IEE, pp. 6–6. doi: 10.1049/ic:20010026.

Differentiating Chromogenic and Silver Dye Bleach Materials by UV Reflectance imaging

Rahul Sharma¹

¹ Department of Conservation and Restoration, University of Amsterdam

Contact: Rahul Sharma, rahulsharmajammu@gmail.com

Extended Abstract

Silver Dye Bleach (SDB) prints, and Chromogenic prints are difficult to differentiate, as at a macro level, they do not have distinctly different features. While identification is possible with micro-scale observation of dye clouds vs dye halos, and backmarks; or by characteristic deterioration patterns; this is not always feasible. This is of concern as SDB and Chromogenic prints have considerably different storage and display stability characteristics. This poster describes a novel protocol to differentiate SDB and Chromogenic Prints.

The inherent instability of chromogenic prints provides a source of identification in the form of a protective layer that blocks UV. This layer was incorporated in the top-coats of prints in 1981. A UV Blocking layer was earlier incorporated above the Magenta layer in Kodacolour type 2 prints. Literature suggests that this layer is not present in SDB prints.

The presence of the UV Block layer was tested by imaging SDB Ilfochrome prints and Chromogenic prints from Kodak and Fuji using a modified DSLR in the UVR mode (i.e. the incident and captured radiation were both UV), illuminated with UV LED lamps at 365nm. After capture, the image was processed using standard protocols. The presence of the UV Block Layer was indicated by no detail in the imaged area, as the UV Blocking layer absorbed the UV radiation. If image detail was recorded, the UV Block layer was not present., as this indicated that the incident UV radiation could interact with the dye layers forming the image, before being reflected and being recorded by the camera.

The presence of the layer was further validated using a Konica Minolta CM 2600d spectrophotometer over consistent spots in the Chromogenic and SDB prints from the AIC Sample set. The spectra show reflectance in the $\approx 360\text{-}380\text{nm}$ band in the SDB prints, which is not present in Chromogenic prints. The presence, or lack thereof of the layer was further tested with multiple known samples, and the UVR mode accurately indicated the same in all cases.

As such, the UVR Mode can be used to detect the presence of the UV Block layer in photographic prints, and can be used as an And/Or test, with contextual information, to differentiate between Chromogenic and SDB prints.

A Long-Term Study of Light-Induced Yellowish Stain Formation That May Develop Over Time in Chromogenic Color Prints and Contemporary Inkjet Prints Exposed to Light on Display and Followed by Storage in the Dark: Further Investigations of the Complex Roles Optical Brighteners (OBAs) and Titanium Dioxide (TiO₂) Play in the Degradation of Color and B&W Photographic Prints Over Time

Henry Wilhelm¹, Effiba Armah², Ken Boydston³, Richard Adams⁴, Charles Wilhelm⁵

¹Director of Preservation Research, Wilhelm Imaging Research, Inc., Grinnell, Iowa U.S.A.

²Mathematical Modeling Specialist, Wilhelm Imaging Research, Inc., Grinnell, Iowa U.S.A.

³Multispectral Color Scientist and Chief Design Engineer, MegaVision, Inc., Santa Barbara, California U.S.A.

⁴Color Scientist and Professor, Ryerson University, Toronto, Ontario Canada

⁵Manager of Testing Operations, Wilhelm Imaging Research, Inc., Grinnell, Iowa U.S.A.

Keywords: yellowish stain formation in photographs, optical brighteners, OBAs, TiO₂, inkjet photographs, microporous ink-receptive coatings, silver-halide color photographs, chromogenic photographs, multispectral imaging, UV excitation of OBAs, degradation of OBAs, degradation in photographs caused by TiO₂.

Extended Abstract

Light-induced yellowish stain formation in photographic papers that gradually developed over time in dark storage was first documented in the 1993 book, “The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures” by H. Wilhelm and C. Brower.

http://www.wilhelm-research.com/pdf/HW_Book_761_Pages_HiRes_v1c.pdf



Fig. 1 - The inkjet print on the right was printed in 2001 with a high-stability fully-pigmented fine art inkset on an RC-base inkjet paper with a microporous ink-receptive coating. At the completion of a high-intensity light-stability test that had continued for more than two years, the print was measured and placed in air-conditioned room-temperature dark storage. Almost all of the yellowish stain observed here occurred during the 18 years of dark storage, after the print was withdrawn from the light stability test (the stained print together with the essentially unchanged control print on the left were photographed in 2021).

At the time, the phenomenon was described by the authors as “RC Base-Associated Image Fading and Yellowish Staining” and, in a closely related problem, as “‘Framing Effects’ in Light Fading with Prints Framed Under Glass or Plastic Sheets” (pp. 72-77). With Kodak Ektacolor 74 RC prints (1977-1982) for example, levels of light-induced yellowish stain continued to steadily increase after 10 years in dark storage at ambient room temperature and relative humidity. Significant reciprocity failures in accelerated light-fading tests, depending on the specific type of print media and colorant set, frequently exacerbate the manifestation of these problems in long-term display and dark storage of photographs.

While light-induced yellowish stain is most easily observed in the white borders of prints, high levels of yellowish stain can have visually devastating effects in, for example, pale blue skies, and in near neutral areas of a print. In museum collections, many examples of prints made in the 1970s and 1980s by Stephen Shore, Joel Meyerowitz, and Richard Misrach, among many others, exhibit high levels of light-induced and thermally caused yellowish stain, generally accompanied by severe dark fading of the cyan image dye.

For this study, more than 10,000 light-exposed and subsequently dark-stored samples from the 50-year period covered by “The Wilhelm Analog and Digital Color Print Materials Reference Collection (1971-2021)” were examined. [http://www.wilhelm-research.com/WIR_Reference_Collection/The_Wilhelm_Analog_and_Digital_Color_Print_Materials_Reference_Collection_1971_to_2021_\(2021-03-10_v20\).pdf](http://www.wilhelm-research.com/WIR_Reference_Collection/The_Wilhelm_Analog_and_Digital_Color_Print_Materials_Reference_Collection_1971_to_2021_(2021-03-10_v20).pdf)

March 10, 2021 v20

THE WILHELM ANALOG AND DIGITAL COLOR PRINT MATERIALS REFERENCE COLLECTION

**All Materials Printed With Color and Monochrome Test Targets
Using the Printers, Processing Chemicals, and Inks of Their Time**

- Traditional Analog and Modern Digital Color Print Materials
- Modern Digital Black and White Print Materials
- Definitive Product and Process Identification and Dating
- Extensive 380–730nm Spectral Data from 800-Patch Color and Neutral Gray Scales
- Comprehensive WIR Eight-Factor Print Permanence Ratings Data
- Sortable/Searchable Databases

***50 Years: From 1971 to 2021
The Only Collection of
Its Kind in the World***

A photograph of a man with glasses, wearing a light blue shirt and a red tie, holding a color calibration target (a small card with various color patches) in front of him. The background is slightly blurred, showing what appears to be a laboratory or office setting.

Itemized Description of the Wilhelm Color Print Materials Reference Collection

(Updated March 10, 2021)

The Wilhelm Analog and Digital Color Print Materials Reference Collection consists of printed analog color, digital color, and digital black and white photographic print materials, with associated accelerated test data and print permanence reports organized in sortable/searchable databases

- 1) Analog color film and print materials from 1971 to 1993 (includes permanence test data): **~475 products**
- 2) Analog and digital color print materials from 1993 to 2000 (includes permanence test data): **~1,220 products**
- 3) Digital color and B&W print materials from 2000 to 2021 (with spectral data from 380 to 730 nm in 10 nm increments for 800-patch neutral, cyan, magenta, yellow, red, green, and blue color scales): **1930 products**
- 4) Total identified film, print paper, and printer/ink/paper products from 1971 to 2021 (50 years): **3,655 products**
- 5) Multiple targets for each printer/ink/media combination subjected to eight separate WIR permanence tests: (1) display permanence (light stability) tests with five different light exposure conditions: glass filter with 5mm air-gap and glass in direct contact with sample surface; (2) acrylic UV filter with 5mm air-gap and acrylic UV filter in direct contact with the sample surface; and (3) unfiltered "bare-bulb" light exposure; (4) multi-temperature Arrhenius dark storage tests; (5) unprotected ozone resistance; (6) resistance to high humidity; (7) water resistance; and (8) determination of the presence or absence of optical brightening agents (OBAs)
- 6) "Natural Aging" test targets are stored in the dark at ambient room temperature (24°C/60% RH) and "Long-Term Subzero Freezer Preservation" test targets for instrument calibration and visual reference are preserved in a freezer at -20°C (-4°F)
- 7) Individual, documented test targets included in the digital portion of the collection: **22,480 test targets**
- 8) TOTAL number of calibration pages and digital and analog test targets in the collection: **27,800 individual items**
- 9) Individual test target measurements in the digital portion of the collection: **~146,484 target measurements** (an average of 35 test targets are measured daily, most with 135 individual color, neutral scale, and d-min paper white patches)
- 10) Individual spectral measurements made of the color and neutral (including full-image monochrome) patches in the test targets for all materials in the digital portion of the collection: **~570 million spectral measurements**
- 11) Data storage, backed-up off-site daily, for spectral measurements and permanence reports: **~158 gigabytes**
- 12) Boxes and rolls of unprinted inkjet paper and canvas which are in addition to the printed samples database: **~1,900 packages**
- 13) Large-format inkjet printers (17 to 64-inch; up to 12 inks) and desktop inkjet, dye-sub, and other digital printers: **~370 printers**
- 14) Microsoft Access databases with WIR developed and programmed Borland Delphi interfaces, providing search/sort capabilities



Fig. 2. One of the unique features of the Wilhelm Reference Collection is the large quantity of test prints have been safeguarded in the passively-humidity-controlled walk-in Wilhelm Imaging Research – Smithsonian Subzero Preservation Vault, which is maintained at -20°C (-4°F) freezer storage temperatures since the prints were first made. These include control samples for all Arrhenius and light-fading reciprocity tests. At this low temperature, the samples will be preserved in pristine condition for many thousands of years into the future and can be used to precisely match the calibration of future multispectral and other measurement devices to the original spectral measurements recorded in the Wilhelm Reference Collection digital database. WIR staff member Barbara C. Stahl is shown with a group of samples preserved in the vault.

This study is focused on identifying the specific types of print media that are highly susceptible to the gradual development of light-induced yellowish stain after light exposure, those that are moderately susceptible, and those that are not noticeably affected by this problem. The prints were subjected to light with three different spectral power distributions – including UV filtration with

Acrylite Gallery UV Filter OP-3 (marketed as Plexiglas OP-3 in Europe), which has a UV cut-off at 390-400nm. In addition, prints were exposed to light both with and without air flow between the prints and the glass and the acrylic OP-3 filters.

When located in the ink-receptive coating of inkjet prints, fluorescing optical brightening agents (OBAs) may be directly involved in light-induced yellowish stain formation (beyond the simple loss of UV-activated fluorescing brightening activity), and in RC-base papers, which are polyethylene coated papers in which the top polyethylene layer contains titanium dioxide (TiO₂) as a white, reflective pigment and essentially all RC papers also contain OBAs.

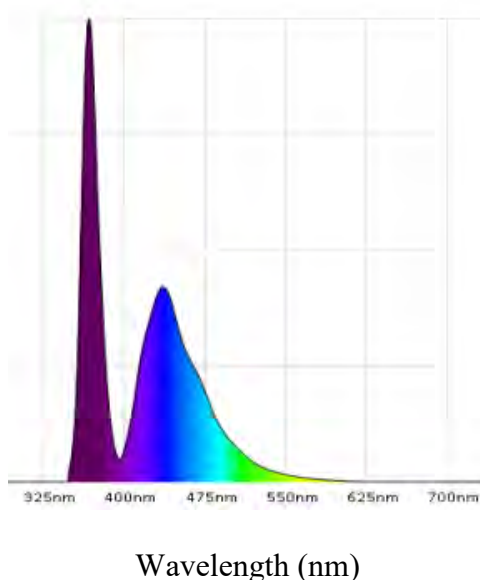


Fig. 3. A spectroradiometric measurement made in the WIR lab of the light reflected from the d-min of a popular “baryta-type” fine art inkjet paper with a microporous ink-receptive coating that has been manufactured with a high OBA content. The tall spike on the left is the 365nm UVA emission that causes the excitation of the “blue” light emitted by the OBAs, which has a peak of 467nm, but which extends at a lower level into the cyan and green wavelengths until about 530nm. The 365nm UVA emission cannot be seen by humans and therefore its presence – or lack thereof – is not apparent. When this print is framed under glass (which cuts off at about 330nm) and is viewed by daylight illumination near a window, the visual effect of the OBAs will be very significant. However, if the print is framed with a UV-filtering acrylic or UV-filtering “museum” glass (which cut off at about 390–400nm), the presence of the OBAs will have little or no visual effect. Blue-pump LEDs and filtered tungsten-halogen lamps emit no UVA wavelengths and for this reason any OBAs present will not be activated. Visual differences depending upon the viewing illumination is significant problem with papers containing OBAs and, together with permanence issues, is an important reason why such papers should be avoided.

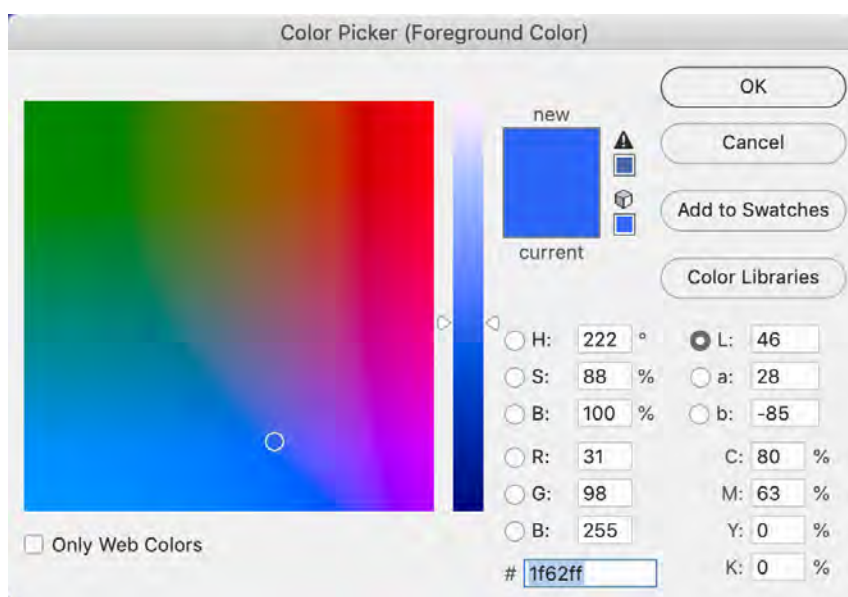


Fig. 4. The “blue” light emitted by the high OBA content of the “baryta-type” inkjet paper described in Fig. 3 was photographed using a digital camera and captured as a non-corrected RAW file. The Color Picker in Photoshop shows the Lab and RGB values for the color.

In this study, the presence, initial levels, and subsequent decay of OBAs are measured and reported using a MegaVision High-Resolution Multispectral Imaging System which has the capability of quantifying the levels of OBA activity in photographs in terms of human visual perception (H. Wilhelm, K. Boydston, K. Armah, and B. Stahl: Proceedings of “Imaging Conference JAPAN 2011”).

These degradation processes are being mathematically modeled for selected media and colorant sets with the eventual goal of providing a method for the long-term prediction of light-induced yellowish stain behavior for both chromogenic and inkjet prints.

Preliminary Conclusions and Recommendations

1. OBAs should be avoided in ALL types of print materials, including inkjet prints, chromogenic prints (silver-halide color prints), and in traditional silver-gelatin B&W fiber-base and RC-base prints. OBAs serve no useful purpose, create many practical difficulties, including significant uncertainties with printmakers using color management in Photoshop and Lightroom, and in general are very harmful to the permanence of prints. The presence of OBAs can cause prints to look different under different lighting conditions.
2. Titanium Dioxide (TiO₂) should not be used as a whitening agent in either the base paper or in the ink-receptive coatings of inkjet prints.
3. Barium Sulfate (BaSO₄) appears to be a satisfactory, non-harmful, whitening agent for inkjet prints and for the baryta layer of silver-gelatin black-and-white prints (baryta coatings have been satisfactorily used with fiber-base silver-gelatin prints since the early 1900s). Current RC-base black-and-white silver-gelatin papers should be strictly avoided because they contain both OBAs and TiO₂.
4. Inkjet prints and chromogenic prints should be protected from exposure to UV radiation by framing them with UV-absorbing acrylic glazing (e.g. Acrylite OP-3, which in Europe is marketed under the Plexiglas OP-3 name), or by illuminating exhibition areas with high-CRI LEDs, in which case traditional types of UV-absorbing glazing are usually not required. However, it remains very important to protect all types of prints from exposure to daylight through window glass (>330nm.)

In the Gallery and Fine Art Marketplace, what, exactly, is an “Archival Pigment Print”?

1. The term “Archival Pigment Print” has in recent years become widely used in the gallery and fine art markets. Regarding assurances of long-term print permanence, the term is in fact quite meaningful.
2. “Archival Pigment Print” is generally taken to mean that an inkjet print has been made with a 100% cotton cellulose paper that contains no OBAs.
3. RC-base (PE-base) inkjet papers are in general avoided, but there are exceptions to this with some photographers and artists.
4. 100% pigment inkjet inks have been used to make the prints. Usually made with large-format printers made by Epson, Canon, or HP, the prints are often produced by the photographers themselves.

5. Because of their extreme susceptibility to ozone and other atmospheric pollutants, along with potentially poor humidity and water resistance, dye-based inkjet inks are NOT acceptable in these markets.
6. For marketing reasons, galleries and fine art dealers strenuously avoid the use of the words “inkjet” or “digital” in the naming of print processes. There are a few exceptions to this, although they are rare.

Papers that are currently believed to be suitable for making “Archival Pigment Prints”

1. All Canson Fine Art Inkjet Papers that are claimed to be made of “100% Cotton Cellulose and OBA and TiO₂-Free.” Canson RC-base inkjet papers, which contain both OBAs and TiO₂, should be avoided.
2. All Epson Legacy Fine Art Inkjet Papers that are claimed to be made of “100% Cotton Cellulose and OBA and TiO₂-Free.”
3. All Hahnemühle Fine Art Inkjet Papers that are claimed to be made of “100% Cotton Cellulose and OBA and TiO₂-Free.” Hahnemühle RC-base inkjet papers, which contain both OBAs and TiO₂, should be avoided.
4. If, for various reasons, the decision is made to use an RC-base (PE-base) inkjet paper, Epson Proofing Paper White Semimatte is tentatively recommended. This unique RC-base paper contains no OBAs in either the ink-receptive coating or in the RC-base paper itself. However, like all other RC-base photo and inkjet papers, it does contain TiO₂ in the thin top polyethylene white layer located beneath the ink-receptive coating. With a surface texture similar to that of many “Luster” papers, it is available in 13x19-inch sheets and in roll formats up to 60-inches (153 cm) wide.

Ongoing research: the next steps....

1. Establish a collaborative research project with a major collecting institution which has the ability to conduct both non-destructive and destructive chemical analysis of the composition of inkjet image-receptive coatings, and with the paper base itself, using documented print samples drawn from the “Wilhelm Analog and Digital Color Print Materials Reference Collection – 1971 to 2021.” This project would be focused on identifying chemical components of microporous inkjet ink-receptive coatings beyond OBAs and TiO₂ that may contribute to yellowish stain formation. These findings will be correlated with stain data from the many thousands of light-exposed, ozone-exposed, and accelerated dark-aged print samples in the Wilhelm reference collection. A summary of these investigations would be co-published by the collecting institution and Wilhelm Imaging Research.
2. Conduct additional spectroradiometric analysis of the spectral emissions of the optical brightening agents found in the print samples in the Wilhelm reference collection, and to determine if this methodology can be employed to identify specific OBAs, and to establish whether some are more stable than others, and to determine if some have a particular propensity to contribute to yellowish stain formation after partial decay on exposure to light and subsequent storage in the dark.
3. Conduct further research on the yellowish stain formation that gradually occurs over time with some inkjet papers when they are subjected to an accelerated ozone-resistance test and are subsequently stored in the dark.

4. Conduct further research on the decay (loss of brightening activity) of OBAs in a wide range of chromogenic, inkjet papers, and other types of digital print media when subjected to an accelerated multi-temperature Arrhenius dark storage tests. A primary goal of this research is to determine if the loss of brightening activity with a variety of media can be predicted for storage of print in ambient (or cold storage) conditions using multi-temperature Arrhenius methodology.

The Teutloff Collection: a multidimensional conservation project in the Grand-Duchy of Luxembourg

Anke Reitz¹, Francesca Vantellini²

¹Centre National de l'audiovisuel (CNA)

²FV Conservation Sàrl.s

Contact: Anke Reitz, anke.reitz@cna.etat.lu; Francesca Vantellini, info@fvconservation.com

Abstract

At the end of 2017, Luxembourg's *Centre national de l'audiovisuel* (CNA) acquired a large collection of contemporary photographs from a private German art collector, Lutz Teutloff. It is a thematic collection inspired by Edward Steichen's historical exhibition "The Family of Man", which is held and displayed by the CNA. For the analysis of the Teutloff Collection, the CNA invited a multidisciplinary and international team of experts and developed and refined a complex workflow.

The project experience and working with the team demands both a high degree of flexibility and availability from all the professionals involved, as the different phases of the conservation/archive project are all carried out in concert. This working method has proved to be quite exceptional, challenging and rewarding at the same time: dealing with different materials, techniques, processes and mountings, the work is accompanied by a constant discussion and reflection of the conservation and handling processes at the CNA archive.

Keywords: photo collection, digital prints, color prints, conservation, institutionalization, framing, mounting, storage, restoration, identification.

Introduction

The *Centre national de l'audiovisuel* (CNA) is a public cultural institution based in Luxembourg. Its core missions are the collection, preservation and the enhancement of the national cultural heritage in the fields of film, sound and photography. This is done in various ways, e.g. through productions, publications, assignments, exhibitions or collaborations with international experts and artists. The photography archive comprises around 500,000 documents, including the *Steichen Collections*, part of the legacy of Luxembourg born artist and curator Edward Steichen. The once itinerant photographic exhibition *The Family of Man* is conserved and displayed as a historical artifact in the North of the Grand-Duchy.

End of 2017, the CNA acquired a large collection of contemporary photographs from a private German art collector, Lutz Teutloff. It is a thematic collection inspired by the historical exhibition "The Family of Man". The Teutloff Collection consists of around 850 artworks, dating from 1968 to 2017, which are very heterogeneous in terms of size, mounting and processes. It includes a majority of digital prints and C-prints, but there are also silver gelatin prints, Polaroids, light boxes, books, artworks on paper and sculptures/objects. Most of the photographs are framed with mat board passe-partouts, or are face mounted or laminated on additional supports.

For the analysis and treatment of the collection, the CNA invited a multidisciplinary and international team of experts made up of five photo conservators, along with archivists, photographers, fine art framers and curators. The work started in 2018 and is planned to last over four years. The experience of the project and the collaboration within the team has proved to be quite exceptional insofar as the single phases of the conservation/archive project are all carried out simultaneously and so necessarily

foster new questionings – both conservation wise and ethically speaking – that are discussed together with the whole team. Moreover, the heterogeneous nature of the collection and the evolution of analog and digital supports form a complex body to be analyzed in terms of conservation, which at the same time, enriches and energizes the project into an ongoing challenge.

Integrating the collection into the archive also means undertaking the institutionalization of a private art collection and what this involves on different levels: e.g. the information that can be gathered on the artwork, its conservation and exhibition history and dealing with artist's rights, etc.

Conservation Project

After acquisition, the Teutloff Collection was moved from Germany to a local storage facility in Luxembourg. This temporary accommodation enabled the organization of the different phases of the work and a first study of the collection in a separate location in order to avoid moving problematic objects into the CNA archives.

Onsite, the first steps of the conservation project were: the drawing up of a list of the artworks, assigning an ID number, the taking of measurements (height, length, width, weight) and photos to identify the different materials and to estimate the quantity of framed and unframed artworks, the identification of any potential organic deterioration or risks ahead of the moving.

This provided a more complete view of the collection and helped us understand how to plan and proceed for the in-depth analysis and conservation. Subsequently, common vocabularies were defined, a workflow was set up for the management of the treatment process, and storage facilities were adapted at the CNA.

At the start of the project, the aim was the integration and conservation of the collection into the CNA archives, after its analysis, cleaning and digitization. But over the course of the first appraisal period, it was noticed that an important part of the artworks had suffered chemical and/or mechanical problems caused by improper handling or conditioning and framing/mounting. Consequently, restoration of the objects was also envisaged and integrated into the mission.

In parallel to and as part of the identification process, all artworks are authenticated and evaluated: the provenance of the photographs is checked, as are the authenticity of the artwork (edition and signature) and its mounting.

The underlying idea of the conservation project was to preserve the objects as a historical and aesthetical entity, so the approach was to intervene as little as possible, but as much as necessary. This meant taking two key considerations into account: the idea of the artist and the subsequent handling of the collector, who was actively involved in shaping the aesthetical aspects of the photographs and of his collection as a whole, through framing, and sometimes laminating, the prints. Thus, it was endeavoured to keep the form of the presentation while renewing mounting or housing materials where necessary.

A common vocabulary and a new condition report

Working together on multiple formats with various techniques generates high-level daily debates about conservation and restoration treatments. So it was paramount to agree on a common vocabulary to be used at the outset for identification and treatment, especially in the case of digital prints where techniques tend to be mixed.

So, after discussions with the team and consequent research¹, a new condition report was designed, encompassing all material variants of the artworks and developing a common vocabulary in the description of the different techniques, alterations and other problems encountered in the collection.

It includes for example a schematic sketch and a description of the object's cross section that helps to visualize and record its structure. Other sections focus on the description of the mounting system with its materials, the visual alterations and the executed and suggested conservation treatments.

Project Workflow

A complex workflow was designed and tailored, covering all phases of the archive project: moving the works to the CNA – unpacking – condition report of the frame – removing the frame – quality check of the frame and mounting materials - unmounting of support (if necessary) – identification and condition report – conservation/restoration measures – authentication and evaluation – digitization recto/verso – new mounting with adequate materials (if necessary) – framing – digitization of the framed work recto/verso – packaging & moving into the archive – adapting the inventory. (Fig. 1)



Fig. 1 – The detailed workflow

As the single phases of the project rely on each other and are all carried out in parallel during a defined period, the workflow demands a high degree of simultaneous availability and flexibility from all the professionals involved.

On the level of the spatial organization, every step was assigned a specific workstation to ensure safety during manipulation and treatment, both for frames and photographs: e.g. the unpacking, packaging, un-framing and reframing are all executed in the same room. To avoid any risk of damaging the unmounted pictures with particles of glass, wood or other elements of the mounting, the authentication, condition report and restoration steps are carried out in a separate conservation laboratory equipped with air filters, climate and light control.

¹ In particular: <http://www.dp3project.org> (Digital print preservation portal); *Twentieth Century Colour Photographs: The Complete Guide to Processes, Identification & Preservation*, Sylvie Pénichon Thames & Hudson, 2013; *The Digital Print: Identification and Preservation*, Martin C. Jürgens; 2009

Common types of deterioration

A majority of the small and middle format photographs in the Teutloff Collection came framed employing materials that did not always stand the test of time or that of preventive conservation. It was observed that most alterations were caused directly by the frame and/or the materials used for mounting the photographs into the frame or on the mat/passe-partout window:

- In the main, mechanical alterations, like scratches, folds, abrasions, tears or cracks were detected.
- In most cases, the removal of prints from their mounting supports was mandatory: e.g. sometimes the artworks were mounted directly against the window mat, causing paper deformations and depressions visible on the surface of the photograph; in other cases, the photographs were glued to acid-containing or acidic decomposed paperboards and presented a lot of cockling, distortions, soiling and residuals.
- It has been noticed that many of the artworks in contact with acidic paperboards, glues and/or adhesive tapes presented yellowing and some chemical stains due to the contact with glue and the lignin of the cardboard.
- Some artworks were mounted in overly small frames, others without distance maintainers between the image surface and the glass/Plexiglas. The result was the adhesion of some part of the photo surface to the glass and the developing of cockling and distortion.

For laminated and face mounted prints, mechanical alterations were the most frequent type of damage observed. Many of them presented scratches and abrasions on the surface and on rare occasions the Plexiglas used for the mounting was irreparably damaged (e.g. cracks and open tears). At other times they presented delamination or shrinkage of the laminated layer along the borders.

Conservation treatments and mounting

The recorded alterations were followed by adapted conservation treatments:

- mechanical alterations (scratches, folds, abrasions, tears, cracks) required measures such as the stabilization and integration of the back of the print or of the image layer, the cleaning of surfaces, or the integration and retouching of missing detail.
- When the photograph was removed from its support, glue residuals or adhesive tape were gently eliminated. In some few cases, for photographs that had suffered distortions, flattening was necessary and achieved by reducing the inner tensions by indirect humidification of the prints in several phases.

In line with the general conservation approach and after conservation treatments, the prints were re-mounted with Japanese paper hinges or with paper corners on a new support made from photographic archival board that was OBA²-free and that had passed the Photographic Activity Test (PAT) in accordance with ISO 18916.

In some cases, and before treatment, the authenticity of the frame and the form of presentation needed to be investigated through research – occasionally in collaboration with the artist – in order to decide the further steps for conservation. When it came to laminated or face mounted prints presenting severe mechanical damage (e.g. breaks or deep scratches on the surface, distortion of the metal support),

² optical brightening agent

contact with the artist was established to decide whether the artwork could be restored (if possible) or should be replaced by a new print in order to respect his/her original intentions.

Storage & conditioning

The beginning of the project was accompanied by reflection on the storage facilities at the CNA. As the whole collection had to be stored in one room, meaning the same environment and conditions for all artworks, conservation priorities had to be defined and the equipment designed according to the needs of the collection. Here too, the entire team was involved to discuss the best long term storage solutions and to define allowable and controlled temperature (T) and relative humidity (RH) values that would be a good compromise for the different materials (wood, metal, paper, ink, etc.).

The guidelines of both chemical and physical safety, the current ISO standards and expert advice led to the decision of cool storage at a temperature of 13°C with an RH at 45%. A vestibule for acclimatization, when photographs need to be moved in or out, is also part of the storage room within the archive.

The arrangement of the artworks inside the archive was established on the basis of their format, as well as their composition/nature. For example, since inks and other chemicals used to produce digital prints may react with other photographs, causing stains, yellowing or other chemical alterations, inkjet prints were separated from silver gelatin and color prints. Another factor influencing the storage are the frames: due to space limitations and in order to facilitate handling for loans and exhibitions, pictures are stored within their frames, to facilitate conservation.

Taking into account the use of the collection, the monitoring and the available budget, the following arrangement and conditioning was applied to the collection objects:

Unframed prints, artist's books/portfolio/boxes and small format laminated photographs:

Flat storage in drawer cabinets in Mylar envelopes inside a conservation box (the number of objects per box being limited to 12). For larger formats in the drawers, an additional rigid cardboard support between the prints is inserted in order to facilitate handling and avoid deformation.

Framed prints, face mounted and laminated photographs:

Vertical storage in mobile shelving using a packaging in light-weight Bondina (in contact with the Plexiglas surface) and Tyvek, plus an archival cardboard to protect the recto of the surface and polyethylene foam corners – or vertical storage on art rack screens.

Objects and sculptures are stored in archive boxes.

Conclusion

The Teutloff Collection represents a valuable addition to the CNA archive fund – especially in dialogue with its existing historical collections. The multidimensional conservation project it entailed came with huge initial challenges - organizational, archival, conservational, historical and curatorial – that were accepted by all participants in the adventure. From the outset and over the course of the last few years, it has developed into a highly enriching mutual project, where the result is more than just the sum of its parts.

The experts and team members involved are (in alphabetical order): Kerstin Bartels, Silvia Berselli, Sophie Dewalque, Isabel Dimas, Laura Di Mola, Sandy Dos Santos, Kurt Gelhausen, Romain Girtgen, Anne Jüster, Sven Erik Klein, Armand Quetsch, Myriam Kraemer, Anke Reitz, Alexandre Useldinger, Francesca Vantellini.

Bibliography

Alcántara, R. (2002) *Standards in preventive conservation: meanings and applications* | ICCROM. Available at: <https://www.iccrom.org/publication/standards-preventive-conservation-meanings-and-applications> (Accessed 22 March 2021).

Archibald, A. (2018) 'A simple protective housing for hung framed artworks', *Journal of Paper Conservation*, 19(2), pp.77-79.

Arenstein, R., Goldberg, L. and Naugle, B. (2018) 'Storage techniques for art, science and history collections (STASHc.com): An online resource for collection storage', *Studies in Conservation*, 63 (sup1), pp.316-319.

Canadian Conservation Institute (1996) *Making protective enclosures for books and paper artifacts*. Canadian Heritage, pp.CCI Notes 11/1. Available at: <https://www.canada.ca/content/dam/cci-icc/documents/services/conservation-preservation-publications/canadian-conservation-institute-notes/11-1-eng.pdf?WT.contentAuthority=4.4.10> (Downloaded 22 March 2021).

Cauliez, N. (2009) *Pour la reliure et la restauration des documents d'archives*. Paris: Direction des Archives de France, p.30.

Cullhed, P. (2001) 'A phase box for the protection of books' | *The Conserve-O-Gram*, 19/23. Available at: <https://www.nps.gov/museum/publications/consveogram/19-23.pdf> (Accessed: 22 March 2021).

Elkin, L., Norris, C. A. (2019) *Preventive conservation: collection storage*. New York: Society for the Preservation of Natural History Collections.

Garside, P. and Hanson, L. (2011) 'A systematic approach to selecting inexpensive conservation storage solutions', *Journal of Conservation and Museum Studies*, 9 (0).

Grattan, D. (2000) 'The stability of photocopied and laser-printed documents and images: General guidelines', *Tech Bulletin #22* | Northern States Conservation Center. Available at: <https://collectioncare.org/tech-bulletin-22-stability-photocopied-and-laser-printed-documents-and-images-general-guidelines> (Accessed 22 March 2021).

Hamel, A. (2019) 'Leaflet 4.10. Matting and framing for works on paper and photographs' *NEDCC Preservation Leaflets* 4.10. Andover: NEDCC Northeast Document Conservation Center. Available at: <https://www.nedcc.org/assets/media/documents/Preservation%20Leaflets/4-10%20Matting%20and%20Framing.pdf> (Accessed 22 March 2021).

Justafré, O. (2013) 'La conservation d'objets hétéroclites dans les dépôts d'archives', *La Gazette des archives*, 229(1), pp.159-169.

Jürgens, M. C. (2009) *The digital print: identification and preservation*. Los Angeles: The Getty Conservation Institute.

Image Permanence Institute (2018) *IPi's Guide to preservation of digitally printed images*. Image Permanence Institute. Available at: https://s3.cad.rit.edu/ipi-assets/publications/dp3_guide.pdf (Downloaded 22 March 2021).

ISO. (2011) 18934 *Imaging materials - Multiple media archives - Storage environment*. Geneva, Switzerland: International Organization for Standardization.

ISO. (2007) 18916 *Imaging materials: Processed imaging materials—Photographic activity test for enclosure materials*. Geneva, Switzerland: International Organization for Standardization.

Lavedrine, B. (2006) *A guide to the preventive conservation of photograph collections*. Los Angeles: The Getty Conservation Institute.

Murphy, E. (2007) 'Basic care of face-mounted photographs at the Museum of Modern Art', *Topics in Photographic Preservation*, 2(24), pp. 160-174. Available at: https://resources.culturalheritage.org/pmgtopics/2007-volume-twelve/12_24_murphy.html (Accessed 22 March 2021).

Nedcc Staff (2020) 'Leaflet 5.1. Storage enclosures for photographic materials', *NEDCC Preservation Leaflets* 5.1. Andover, MA: NEDCC Northeast Document Conservation Center. Available at: https://www.nedcc.org/assets/media/documents/Preservation%20Leaflets/5_5_photostorage_2018.pdf (Downloaded 22 March 2021).

Nedcc Staff (2019) 'Leaflet 5.3. Care of photographs.', *NEDCC Preservation Leaflets* 5.3. Andover, MA: Northeast Document Conservation Center. Available at: https://www.nedcc.org/assets/media/documents/Preservation%20Leaflets/5_5_photostorage_2018.pdf (Downloaded 22 March 2021).

Norris, D. (1996) 'Appendix R: Curatorial care of photographic collections' *NPS, Museum Handbook - Part I. Museum Collection*. Available at: <https://www.nps.gov/museum/publications/MHI/Appendix%20R.pdf> (Downloaded 22 March 2021).

Norris, D., Gillis, K. and Luxner, A. (1994) *Photographic materials conservation catalog*. Washington, D.C.: American Institute for Conservation, Photographic Materials Group.

Penichon, S. (2013) *Twentieth-Century color photographs - Identification and care*. Los Angeles: The Getty Conservation Institute.

Pénichon, S., Jürgens, M. and Murray, A. (2002) 'Light and dark stability of laminated and face-mounted photographs: a preliminary investigation', *Studies in Conservation*, 47(sup3), pp.154-159.

Ramel, S. (2007) *Point de vue sur la conservation-restauration des matières plastiques*, CeROArt, 1 | 2007, Available at: <http://journals.openedition.org/ceroart/395>; DOI: <https://doi.org/10.4000/ceroart.395>.

Reilly, J.M. (1998) *Storage guide for color photographic materials* / James M. Reilly, New York: New York State Program for the Conservation and Preservation of Library Research Materials Albany.

Schönbohm, D., Glück, E., Kühner, M. and Banik, G. (2010) 'Protective enclosures for art on paper' *Restaurator International Journal for the Preservation of Archives and Library Materials*, 31(3-4); DOI: 10.1515/rest.2010.020.

Van Der Reyden, D. and Vogt-O'Connor, D. (1996) 'How to care for bound archival materials', *Conserve-O-Gram*, 19/18. Available at: <https://www.nps.gov/museum/publications/consveogram/19-18.pdf> (Accessed 22 March 2021).

Vogt-O'Connor, D. (1996) 'Care of archival compact discs', *Conserve-O-Gram*, 19/19. Available at: <https://www.nps.gov/museum/publications/consveogram/19-19.pdf> (Accessed 22 March 2021).

Von Waldthausen, C. (2003) 'Exhibition of photographic materials in library and archive collections', *Topics in Photographic Preservation*, Volume 10, pp.178-190. Available at: http://resources.culturalheritage.org/pmgtopics/2003-volume-ten/10_18_Waldthausen.pdf (Accessed 22 March 2021).

Watkins, S. (2021) *PMG Exhibition guidelines for photographic materials*. Available at: http://www.conservation-wiki.com/wiki/PMG_Exhibition_Guidelines_for_Photographic_Materials (published_2004) (Accessed 22 March 2021).

Wilhelm, H., Brower, C. (1993) *The permanence and care of color photographs: Traditional and Digital Color Prints, Color Negatives, Slides and Motion Pictures*. Grinnell, Iowa: Preservation Pub. Co.

“Making the beautiful even more beautiful”: Luriki practice of hand tinting analogue photography in the late Soviet epoch

Oleksandra Osadcha

Museum of Kharkiv School of Photography, Kharkiv, Ukraine

Keywords: Soviet photography, hand-colouring, luriki, Boris Mikhailov, Kharkiv School of Photography

The quote “Making the beautiful even more beautiful” belongs to the celebrated contemporary Ukrainian photographer Boris Mikhailov. In his conversation with an art historian and curator Alla Efimova he discusses the tradition of enlarging, retouching and overpainting photographic portraits. The term for this tradition — *luriki* — became the title to one of the artist’s milestone series, created between 1971 and 1985 (Efimova, 2004). For the series Mikhailov used a number of the appropriated prints he had collected being involved in the luriki business. The author’s presence in the project is basically limited to selecting and colourising images. As the artist states, utilizing vernacular photography was aimed at capturing and exploring “the Soviet mode of life” (Mikhailov, 2020). The practice of tinting family portraits was a noticeable part of the epoch’s visual culture, combining both the spheres of private life and common taste.

The very idea of hand colouring photographs isn’t a Soviet invention and as almost old as the photography technology itself. Yet, the need in it quickly disappeared with the introduction by Eastman Kodak of the subtractive colour process, which prompted the rapid popularisation of colour photography. And yet its expansion significantly slowed in the USSR. So-called Sovcolor films were based largely on the technology of German Agfacolor — actually, the production of the first colour negative film “Svema”, indexed as “DL-1” (DayLight) was launched in 1947 at the film factory number 3 at Shostka (Ukraine) on the equipment, which had been demounted in Germany. The second film factory, which manufactured colour films was TASMA (located in Kazan, Russia). And yet, since, as the critic Inna Vasileva notes, film production was always the “by-product” of the military industry (*Noveyshaya istoria otechestvennogo kino*, 2004), so the mass consumer had to be satisfied with the low-quality materials that weren’t competitive with their foreign analogues, pricey and difficult to craft at home.

Therefore, Mikhailov’s statement about “old-fashioned” lagging technology is completely relevant. Despite powerful development of photomateur’s movement since the 1950s, a remarkable role in the circulation of photographic images was played by the communal service centres, which functioned in the cities, providing people with the variety of services — from haircut, laundry, tailoring to taking portraits for family albums or documents, film developing and printing. They also offered making “colourized portraits”, done in oil paints. The price depended on the size of print and number of people on photograph. However, a significant part of the population, which lived in small towns and villages across the vast territory of the country, barely had any access to the professional photographic services. This fact prompted the emergence of the unofficial business of luriki, which flourished in Kharkiv throughout the Breznev’s era (mid-1960s — early 1980s) and well into the late 1980s — early 1990s. The city was often considered the capital of this “craft”.

Despite its mass character, luriki stayed out of the focus of profound academic research. The only detailed description of the phenomenon available so far, is the “Luriki” novel published online by the Kharkiv photographer Jury Rupin. He, being himself a part of that business, narrates a story from a person of an engineer, who got involved into the shadow world of “lurievshiki”, as people, who

worked with luriki, were called. We know that at least 6 representatives of the Kharkiv photographic community, Boris Mikhailov, Jury Rupin, Oleg Maliovany, Oleh Hrunzovskyi, Misha Pedan, Boris Redko participated in that unofficial “side hustle”. It was an extensive network of the professionals, each of whom was responsible for the particular stage of the process. In the first stage, called ‘nabor’, people travelled to the distant regions of the USSR to collect orders — for instance, we know some of his pieces Oleh Hrunzovskyi took while travelling to the Western Siberia, Uzbekistan, Dagestan. As the photographer recalls, industrialized cities with institutes, academic campuses mostly had their own ateliers, so naborshiki had to look for the remote locations.¹

Fig. 1 – A sample of lurik. Collection of the Museum of Kharkiv School of Photography (MOKSOP).

Luriki were mainly made of small, often worn-out, photographs for documents or old prints (Fig. 1). Naborshik (gatherer) were equipped with “pokazukha” — a folder with the samples of portraits,



which they demonstrated going from house to house and looking for potential clients. They had to note carefully the instructions of each order: sometimes the clients asked to merge two portraits (those were called “soedy” — “combines”), to make one look younger, to add some details (like a tie), to open a person's eyes on the post-mortem photograph, or even combine them with a portrait of Stalin.

Upon the return to the city, gatherers passed the photographs to ‘prokrutchiky’ — ‘errand men’, responsible for transferring orders from one executor to another. They brought the batch of the orders to the photographers, who enlarged and printed replicas of images using reproducing equipment (Fig. 2). The most popular size of lurik was 18 by 24 centimeters. Apart from montaging images, the photographer often had to eliminate some of the details or the whole background. There were two main solutions to that task: the first one was masking certain areas of the film emulsion or applying diluted iodine over the unnecessary parts of a print itself.

¹ From the personal conversation with Oleh Hrunzovskyi in August, 2019.



Fig. 2 – Roman Pyatkovka. A photograph of reproducing equipment. Courtesy of the artist.

After all those manipulations the key stage of tinting and retouching began. Both operations were often conveyed by one person (Fig. 3). Colourising was done with aniline pigments, that were mainly produced for light manufacturing (for dyeing clothing, stockings) sold at haberdashery stores, or as food colouring that could be purchased at street markets. Pokraschiky' ('overpainters', who colourised prints) preliminary chose several basic hues — skin tone, pink, yellow and blue, that were the subdued versions of the triad of primary colours. The large areas of a print (like background or a haircut) was painted with cotton swabs, while smaller elements were done with thin brushes. As artist Svitlana Dollhopf, who had a solid experience as an overpainter and retoucher, accentuates, the main criteria of quality was the ability for neat colouring without crossing the borders of the details².

The aspect of timing was crucial in the luriki business, since it was important to get the whole batch of the orders done as soon as possible. A simple colouring of background, face, haircut and clothing took around a minute. Retouching was a significantly more delicate and timeconsuming process, during which the details were removed or added according to a client's instructions, and montage seams were smoothed. The print was elaborated with charcoal or sanguine of different hues, shaded with fingertips. Some retouchers had their own system, in which each finger corresponded to the specific hue of the material. As another tool for shading retouchers used swabs made of blotting paper, rolled into straws, sharpened and consequently softened with sandpaper. To speed up the production, they had templates for drawing a shadows and other folds, where a clear outline was needed.

² From the personal conversation with Svitlana Dollhopf in March, 2021.



Fig. 2 – Roman Pyatkovka. A working place of an overpainter. Courtesy of the artist.

After retouching, the print was taken to a ‘zakatchik’ — ‘a sealer’, who arranged a protective cover for portraits. Lurik was placed on a cardboard for better firmness and sealed into a piece of cellophane with the help of an iron. In some cases, a stand was cut out in cardboard, so the portrait could be placed on a table. And yet some clients preferred to hang the images on the wall as a kind of an altarpiece that commemorates a family. Eventually, the orders were delivered to people. In the professional slang that stage was called “kidka” — from Russian “kidat” — to throw.

Studying luriki requires understanding that, in the country, where non-governmental business was prohibited, they were one of the rare manifestations of private entrepreneurship. The utilitarian, “low-brow” practice is a unique research case, which combines aesthetical aspect of the mass taste, historical context of the circulation of photographic production in the Soviet society, and economical relations around that deeply hierarchized system.

Bibliography

- Efimova, A. (2004) ‘Feeling Around’, *Beyond Memory: Soviet Nonconformist Photography and Photo-related Works of Art*. New Brunswick: Rutgers University Press, 2004, p. 271.
- Mikhailov, B. (2020) Boris Mikhailov: From Photography Talks. *MOKSOP*. Available at: <https://www.moksop.org/en/borys-mykhaylov-z-rozmov-pro-fotohrafiiu/> (Accessed on 15 Mar. 2021).
- Noveyshaya istoria otechestvennogo kino* (2004). Saint-Petersburg: Seans, 2004, p. 295.
- Rupin, J. (2007) ‘Luriki’. *Samlib*. Available at: http://samlib.ru/r/rupin_j_k/luriki.shtml (Accessed on 15 Mar. 2021).

Prokudin-Gorskii's technique of colour photography: colour separation, additive projection and pigment printing

Nadezhda Stanulevich

Peter the Great Museum of Anthropology and Ethnography (the Kunstkamera)

Contact: Nadezhda Stanulevich, nstanulevich@gmail.com

Abstract

Russian scientist and photographer Sergei Prokudin-Gorskii studied the additive method of colour photography at Adolf Miethe's laboratory in Berlin at the beginning of twentieth century. In December 1902, Prokudin-Gorskii gave the first colour presentation at the photography section of the Imperial Russian Technical Society. Prokudin-Gorskii photographed the Russian Empire between 1905 and 1915. Based on colour separation, he had successful optical colour projection and produced different types of colour prints. The Library of Congress purchased the main part of the negatives and reference print albums from his sons in 1948. Details of his technique contain on patents, articles and reports.

Keywords: colour photography, colour separation, additive projection, pigment printing, Prokudin-Gorskii.

Introduction

To record the word in colour was a mimetic dream shared by Russian photographer Sergei Prokudin-Gorskii (1863-1944). Prokudin-Gorskii's technique for producing colour images was a type of additive colour screen processes. During his activity, he took more than 3500 colour photographs and most of the colour separate glass negative preserved by the Library of Congress. Thanks to new digital technologies, Prokudin-Gorskii's photographic legacy is becoming known throughout the world. Still, most researches focused on the sampler of Russia's past in colour, not on the details of the photographic process. This is mainly because most sources on this topic exist only in Russian and have not been previously translated.

Prokudin-Gorskii science biography

Scientist, inventor, entrepreneur, and colour photographer, Sergei Prokudin-Gorskii was born into a noble Russian family on 18 (30) August 1863 in Vladimirskaya province. In October 1886, Prokudin-Gorskii enrolled as an irregular student at Saint Petersburg University. In the first semester, he listened to chemistry lectures by Dimitri Mendeleev, inventor of the periodic table (Prokudin-Gorskii, 1886). Clearly, Mendeleev influenced the young Prokudin-Gorskii's interest in chemistry. In November 1888, Prokudin-Gorskii stopped his education at University (Prokudin-Gorskii, 1888). Two months early, he started to be an irregular student at the Imperial Medical Army College. In the fall semester of 1889, he also stopped his education at College ('Certificate', 1890). He did not complete the cycle of higher education, but the knowledge gained formed his main interests and skills: chemistry and photography.

In 1890 Prokudin-Gorskii married Anna Lavrova, daughter of an industrialist Alexander Lavrov, an active member of the Imperial Russian Technical Society (IRTS). Lavrov appointed his son-in-law director of the executive board of his steelworks, located in Gatchina near Saint Petersburg. In 1896 Prokudin-Gorskii started to be a member of the chemistry section of the IRTS. Two years later, he was a member of its photography section, presented an illustration report, 'On Photographing Meteor Showers'. In the same year, he was one of the exhibitors at the 5th Photographical Exhibition at the IRTS with black-and-white photographs from oil paintings.

Prokudin-Gorskii maybe took his first photographs near summer 1892. He mentioned photographing in Yalta in one of his first photo article (Prokudin-Gorskii, 1897). This could be due to professional interest and an increased interest in photography in everyday life. In addition, the fact of the birth of children in the family of Sergei Prokudin-Gorskii could serve as an appeal to photography - the eldest son Dmitry was born on 22nd January 1892 (Korlyakov, 2009).

Since 1898, Sergei Prokudin-Gorskii wrote reviews to international photographic news for the IRTS. I supposed that by these researches, he concentrated his attention on colour photography.

On 30th October 1898, he had a report at the IRTS about new Ives' magic lantern. More than twenty years later he mentioned in the British Journal of Photography pages (Prokoudine Gorsky, 1920):

Certainly, such an arrangement, i.e., exact superposing - on one and all - of three pictures through three coloured screens is a slow process, but if it is done at once it series continually, and therefore the most advantageous condition for such projection is a permanent hall where the apparatus is fixed and will not be moved. With such an optical apparatus colour projection was shown for the first time by Mr. F. E. Ives. This apparatus was modified by myself, and from the point of view of rapidity of arrangements and quality it gave better results, and, having shown my pictures in different parts of Russia by means of this apparatus. I had absolutely no competitors, not even Autochrome, which made its appearance long ago, and which remains within close limits of private circles. More than a hundred projections shown by myself playing convinced me of the great interest of audience, regardless of their composition. It is only necessary that the show be accompanied by verbal explanation; no lecture is essential, but just a simple explanation of what it being shown.

On 29th January 1899, Prokudin-Gorskii demonstrated to IRTS' members a colour photography of a parrot by John Joly. Interestingly, this type of bird was a favourite subject for photographing by all scientists who created colour photography. For example, Alexandre-Edmond Becquerel (1820-1891) exhibited at the International Exhibition in Paris in 1855 one of his photographic plates depicting a parrot (Pénichon, 2013). One of the leading figures in three-colour photographic processes - Louis Ducos du Hauron (1837-1920) demonstrated at the Conservatoire national des arts et métiers in 1881 héliochrome depicting a parrot and a rooster, made in 1879 (Lécuyer, 1945). The choice of the parrot by the photographers for the shooting was probably caused by the multi-coloured colour of this bird, which made it possible to demonstrate success in obtaining colour images and the reliability of colour reproduction of one or another photographic method.

Colour separation, additive projection and pigment printing

In early 1900s, Prokudin-Gorskii opened in Saint Petersburg a photographic laboratory called 'Prokudin-Gorskii's Art Photomechanical Studio'. At the first time, it produced photocopies from artworks, and then colour postcards and slides usually based on Prokudin-Gorskii's separate negatives. Also, Studio specialised on making photolithography and microphotography.

At the beginning of the twentieth century, Prokudin-Gorskii studied an additive method of colour photography intensely from Adolf Miethe in Berlin. By analysing the dates, titles, and lists of participants of the IRTS' meetings, we understand that Prokudin-Gorskii's education in Berlin ended in December 1902. Documents about his travel to Europe in the late 1880s, as mentioned in some articles (Adamson, 2002, p. 108; Allshouse, 1980, p. X), were not found during my ten-year

research. Maybe, he had some travels, but for the management of his father-in-law foundry, for the chemical and technical educational reasons.

As Adolf Miethe, Prokudin-Gorskii created his photographs by using a camera which exposed one oblong glass negative plate three times in rapid succession through three colour filters. Prokudin-Gorskii used shutter by Thornton-Pickard and different objectives by Steinheil or Voigtländer (Prokudin-Gorskii, 1906c).

After 1904 Prokudin-Gorskii began to work on the development of colour-sensitive photographic plates. Within a year, he had perfected a new method that gave equal sensitivity throughout the spectrum. Commenting on his colour images published in the journal *Fotograf-Liubitel*’, Prokudin-Gorskii mentioned that he developed a special emulsion that hypersensitised the Ilford “red label” plates (Prokudin-Gorskii, 1906c). We found the same information (Evdokimov, 1914) on paper about trichromatic prints by Alexander Evdokimov, Gorskii’s partner between 1902 and 1914. Prokudin-Gorskii described drying the plates after sensitisation in his report at VI International Congress of Pure and Applied Chemistry in Rome in 1906 (Prokudin-Gorskii, 1906a) and one of the articles on colour photography (Prokudin-Gorskii, 1906b). The patent for the process of sensitisation of the emulsion was not detected in different databases and archives.

His first known lecture on the three-colour photography delivered on 13th December 1902, reported on colour slides by Adolf Miethe (Adamson and Zinkham, 2002). Prokudin-Gorskii ordered the projector in a German factory. Later, this apparatus was destroyed after he left Russia in 1918 (‘Proekt sozdaniia ...’, 1932). A screen for projection was painted in white colour without blue pigment and then mounted to a black frame. A black drop-down curtain was lifted and closed for the projection of each image (‘The photography section of the IRTS meeting journal on 4th February 1905’, 1905). Prokudin-Gorskii was one of the photographers who lectured about the regions he travelled, using the colour slides he had produced. His son Dmitry (1892-1963) often operated the lantern. Sergei Prokudin-Gorskii always had chosen a special series of pictures that served the purpose of an action to viewers.

At the first shows, Prokudin-Gorskii, probably, a magic lantern with three lenses with attached colour filters that matched the red-green-blue separations on the glass slide. When projected on a white screen in perfect registration, they formed a single, full-colour image. Later he tried to create a system with one beam and multilayer transparencies. As he mentioned on *The British Journal of Photography* publication (Prokoudine Gorsky, 1920):

The methods for the producing of transparency for the projection colour images existing at present can be divided into three groups:

1. Autochrome and other similar methods [...]
2. Different methods of gluing together films to films or to a glass [...]
3. Colouring of the diapositives, even if made sometimes with very transparent colours [...]

Sergei Prokudin-Gorskii started to obtain patents in Great Britain, USA, France and Russia before the First World War for production of coloured slides, improvements in and relating to optical systems for the photographic camera, making multiple copies of colour slides etc. Some of them mentioned on *The history of three-color photography* (Wall, 1925) and *History of colour photography* (Friedman, 1945). For example, from the Russian patent in 1913, we can derive that he started to use colour separate negatives exposed through red, green and blue filters for printing two

autotype clichés (for magenta and yellow inks) instead of making a glass slide like a “sandwich”. Through gelatin solution, magenta and yellow images transferred from paper support to one glass plate. The third part was a cyan slide printed from a half-tone negative that had been exposed through a red filter. The last step was mounting both-glass slides - the magenta and yellow on one and the cyan slide on the other – together so that its result is one lantern slide. Sergei Prokudin-Gorskii wrote that in projection, the slides looked like a pigment colour image.

The process of making clichés for colour printing described by Alexander Evdokimov in the first decade of the twentieth century contained the following steps: colour separation by the photographed through the three colour filters; contact printing of transparencies from each separated negatives; shooting from the scales; printing autotype negatives and then making clichés on copper or zinc (Evdokimov, 1914). In 1905 and 1906, Prokudin-Gorskii mentioned that dyes by Frankenstein-London Company were used for the colour printing on his studio (Fig. 1). The Prokudin-Gorskii's Studio was a typical printing enterprise before the showing colour slides for Emperor Nicolas II on May 1909. After the audience, the number of government orders increased.



Fig. 1. - Vyborg castle. Example of colour printing.

Prokudin-Gorskii, S. (1905) *Photomechanical work*. Saint Petersburg: Printing House “Pudkic Benefit”.

After moving to Europe in September 1919, Prokudin-Gorskii, with his sons, founded a company, ‘Société de Photochimie Elka’ named Sergei Prokudin-Gorskii’s youngest daughter Helena (later a company renamed to “Gorsky Frères”) in Nice in 1924. Before the 1950s, they specialized in commercial printing for Nestlé, Fléchet, L’Illustration and Figaro.

Since the second part of the 1920s, the photographer started to use film in his processes. Prokudin-Gorskii mentioned that fact in his notebooks. Copy of these notes from the family collection in Paris was presented by Svetlana Garanina, the first Russian biographer of Sergei Prokudin-Gorskii,

to the Polytechnic Museum in Moscow in 1995 (Danilina, 1995). These documents show the history of Prokudin-Gorskii's patents usage, describing the modifications of his photographic processes during the 1920s. In addition, notes contributed information about the contract between Prokudin-Gorskii and Lumiere's label for the making film with Prokudin-Gorskii's label – Elka.

On 18th December 1926, Prokudin-Gorskii had a report at the French Photography Society about making natural-colour prints on paper. In the photographer's opinion, the photomechanical property of the Elka paper was the possibility of the image being transferred to any desired surface. The image transferred to a metallic surface and developed in hot water to remove all soluble gelatin at describing process. The metallic silver of the films transformed into halide salt. Finally, the plates are rinsed very briefly, merely to remove the excess of the solution, and each is immersed in a dye solution, orange-red, yellow and blue. When the three dyed images have thus been produced, all that remains is transferring one of the prints to the final support and superpose the other two upon it ('Colour Photography on Paper', 1926). Despite the active popularisation of his photographic paper, Prokudin-Gorskii mentioned that he preferred to experiment with Kodak transferotype paper for making slides since 1927 (Prokudin-Gorskii, no date).



Fig. 2. Vyborg castle. 1904. Sergei Prokudin-Gorskii. Photographic print. Prokudin-Gorskii Collection (Library of Congress). LOT 10333, no. 91

Heritage of Sergei Prokudin-Gorskii

The Library of Congress purchased Prokudin-Gorskii's collection the photographer's sons in 1948, after his dead in 1944. The entire collection of glass negatives and albums with sepia-tone prints was digitized in 1999 and is available worldwide on the Internet.

This collection includes 1902 black and white glass negatives and more than 3100 sepia-tone prints without any colour or black and white slides. The size of the glass negatives is 9 x 24 cm. with the dimensions of each image frame is 8.5 cm. wide and from 7.5 cm. to 8 cm. tall. Prokudin-Gorskii mentioned in his emigrant memoirs that after shooting, he printed copies of images and collected them to the album. In this way, the albums from the Library of Congress Collection were made. There were photographic prints from red filter glass negatives the author's numbering and titling. Although, sometimes Prokudin-Gorskii wrote this information from memory and made mistakes, as researchers determine now. The sepia-tone prints with size 8 x 8 cm. mounted on fourteen albums (usually six photos on each page of the album).

Fifteen black and white slides of Leo Tolstoi's Estate in Iasnaia Poliana with size 8 x 8 cm are preserved at the Institute of Russian Literature Collection, and 24 colour slides making in the 1930s on film are the part of private collection of Prokudin-Gorskii's grandson, Michelle Soussaline.

Colour postcards, posters, illustrations for publications printed by Prokudin-Gorskii based on his separated negatives are part of the collections of archives and libraries in different countries.

Conclusion

Sergei Prokudin-Gorski was a talented inventor who used his scientist background. The main interest of additive process is that a black image is used directly as the base of the colour image. Prokudin-Gorskii wrote in emigration (Prokoudine Gorsky, 1920) that having been occupied with the problem of colour cinematograph since 1912; he concluded that the principle of three separate negatives was the most advantageous one because it allowed large amplitude in the ratio of exposures. Moreover, by his opinion, these negatives can be utilised for another very useful purpose: optical colour projection and producing colour prints typographically.

Bibliography

Adamson, J. and Zinkham, H. (2002) 'The Prokudin-Gorskii legacy: color photographs of the Russian Empire, 1905-1915', *Comma*, 3/4, p. 109.

Allshouse, R.H. (1980) *Photographs for the Tsar: The Pioneering Color Photography of Sergei Mikhailovich Prokudin-Gorskii Commissioned by Tsar Nicholas II*. London: Dial Press, p. XI.

'Certificate' (1890): Ф. 358, Оп. 1, Д. 1031. Л. 7. The Central State Historical Archive in Saint Petersburg.

'Colour Photography on Paper' (1926), *The British Journal of Photography, Monthly Supplement on Colour Photography*, 161, p. 31.

Danilina, V. (1995) *Opis' lichnogo fonda Sergeia Prokudina-Gorskogo (dokumenty i fotografii)* [List of Personal fund of Sergei Prokudin-Gorskii (documents and photographs)]: ПИМ-033441/1-33. The Polytechnic Museum, Moscow.

Evdokimov, A. (1914) 'Trehkrasochnaia tipografaskaia pechat' i ee tekhnika [Three-colour typographical print (Dreifarbendruck) and its technology]', *Zapiski Imperatorskogo Russkogo Tekhnicheskogo Obshchestva* [Bulletin of the Imperial Russian Technical Society], 1, p. 15-18.

Friedman, J. S. (1945) *History of color photography*. Boston: American Photographic Publish Company.

Korlyakov, A. (2009) *Velikii russkii iskhod* [Great Russian Exodus. Europe]. Paris: YMCA-PRESS, 2009. p. 978.

Lécuyer, R. (1945) *Histoire de la photographie*. Paris: Baschet et C. p. 232.

Pénichon, S. (2013) *Twentieth century colour photographs. The complete guide to processes, identification & preservation*. London: Thames & Hudson Ltd. p. 8.

'Proekt sozdaniia Obshchestva s ogranichennoi otvetstvennost'iu po organizatsii tsvetnykh proektsii' [Project of creation of the Limited Company for organisation the showing colour projections]' (1932): Ф. 33, Оп. 1, Д. 5. The Polytechnic Museum, The Science Archive, Moscow.

Prokudin-Gorskii, S. (1886) *Zaiavlenie inspektoru studentov* [Application to the student inspector]: Ф. 14, Оп. 3, Д. 26010. Л. 2. The Central State Historical Archive in Saint Petersburg.

Prokudin-Gorskii, S. (1888) *Proshenie rektoru Imperatorskogo Sankt-Peterburgskogo universiteta* [Application to the rector of the Saint Petersburg University]: Ф. 14, Оп. 3, Д. 26010. Л. 24. The Central State Historical Archive in Saint Petersburg.

Prokudin-Gorskii, S. (1906a) ‘VI International Congress of Pure and Applied Chemistry in Rome’, *Fotograf-Liubitel*, 5, p. 158.

Prokudin-Gorskii, S. (1906b) ‘Fotografii v natural'nykh tsvetakh [Photography in natural colours]’, *Fotograf-Liubitel*, 6, p. 179.

Prokudin-Gorskii, S. (1906c) ‘About the pictures’, *Fotograf-Liubitel* [Photographer Amateur], 10, p. 313.

Prokoudine Gorsky, S. (1920) ‘Importance of colour photography for schools and the community in general’, *The British Journal of Photography, Monthly Supplement on Colour Photography*, 161, pp. 13-15 and 19-20.

Prokudin-Gorskii, S. (no date) *Rabochaia zapisnaia knizhka S.M. Prokudina-Gorskogo* [Prokudin-Gorskii's work notebook]: Ф. 33, Оп. 1, Д. 6. Л. 16. The Polytechnic Museum, The Science Archive, Moscow.

‘Zhurnaly zasedanii V (Fotograficheskogo) otdela I.R.T.O. Zasedanie 4 fevralia 1905 goda. [The photography section of the IRTS meeting journal on 4th February 1905]’ (1905), *Zapiski Imperatorskogo Russkogo Tekhnicheskogo Obshchestva* [Bulletin of the Imperial Russian Technical Society], 6, p. 227-228.

Wall, E. J. (1925) *The history of three-color photography*. Boston: American Photographic Publish Company.

EXTENDED ABSTRACT

The Start of the Rainbow: Possibilities of Color Motion Photography for the Amateur

Louisa Trott

University of Tennessee

Contact: Louisa Trott, ltrott1@utk.edu

Abstract

The earliest era of amateur moviemaking offered an inventive array of color possibilities for the film enthusiast. From the fifteen discreet colors of an Automatic Colorator and the subtlety of tinting & toning to the subdued hues of Kodacolor and Vitacolor, then later the accessory-free magic of Dufaycolor's réseau.

This presentation provides a chronology of amateur cinematography's kaleidoscopic color history. Drawing primarily on articles and advertisements in amateur moviemakers' publications and the popular press (in the United States and Europe), to provide a timeline of color motion picture photography and effects available to amateur cinematographers in the 1920s and '30s. The presentation considers the equipment used to make and project the movies, as well as the processes themselves.

Keywords: color film, amateur film, additive color processes, historical color processes.

Introduction

The market for amateur moviemaking quickly flourished after the introduction of 9.5mm and 16mm in 1922 and 1923. New publications were dedicated to the amateur filmmaker, and industry/professional journals and magazines introduced amateur sections, providing advice to the amateur and keeping them informed of the latest and forthcoming technological developments. Most writers in these publications eagerly anticipated the arrival of color, "Do *you* want natural color motion-pictures? Yes, you do! [...] Color, good color, is obtainable!" (s.n., 1929, p. 171) However, there were detractors and doubters too, for reasons of both practicality and cost, but also aesthetics. Some writers just didn't consider color necessary for the amateur. For example, in *Photo Era*'s amateur column, Herbert McKay, discusses why he doesn't think the amateur cinematographer needs color, concluding, "let us be content to accept the monochromatic film [...] as our standard." (McKay, 1926, p.285) Some writers asserted that amateur color filmmakers were very much the pioneers and that they had the power to drive the market and even influence the professional industry. For example, Carl Oswald believed that, "... the efforts of the amateur [...] lead to advances which the commercial organizations cannot afford to anticipate by the establishment of experimental laboratories." (Oswald, 1928, p. 15)

A Chronology of Color in Early Amateur Moviemaking

Date	Process	Type
1920s	Hand-coloring	Manually applied directly to film
1920s – 1930s	Tinting / toning	Processed by filmmaker or sent to vendor
1927 - 1929	Filter projector attachments	Projector attachment
1928 - 1935	Kodacolor	Lenticular
1928 - 1932	DuPont Vitacolor	Rotating filter on camera and projector
1931	Mroz-farbenfilm	Rotating filter on camera; color applied to film base
1932 - 1933	Morgana Color	Rotating filter on camera and projector
1932?	Agfacolor	Lenticular
1934 - 1951	Dufaycolor	Three-color réseau inherent in film base

Fig. 1 – A chronology of color processes available to the amateur filmmaker, pre-1935.

Dates indicate the introduction of a process and its approximate obsolescence

The earliest methods for producing color in amateur film can be categorized into four broad groups: the direct application of color to the film or the projected image, lenticular, rotating filter mechanisms, and Dufaycolor's unique réseau. (Fig. 1)

Direct Application of Color to the Film or Projected Image

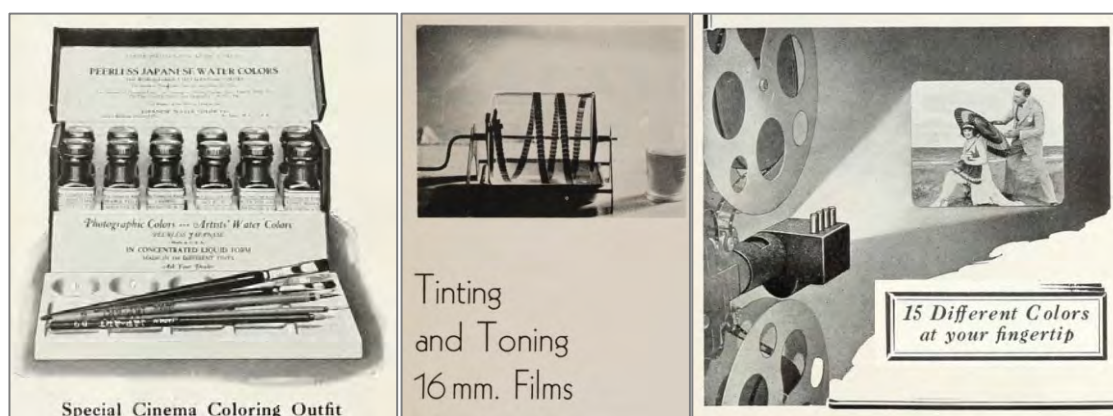


Fig. 2 – Advertisements and article in amateur movie publications

(*Movie Makers*, 1928, p. 476; Stull, *American Cinematographer*, 1933, p. 18; *Movie Makers*, 1927, p. 65)

Applying color to individual frames (hand-coloring), lengths of the film (tinting/toning), or the use of colored filters attached to the projector, allowed the amateur to use blocks of color to interpret a subject or a mood. For example, red for fire, blue for a seascape or night scene. Hand-coloring was an intricate and time-consuming process, but tinting and toning could be done relatively easily by the keen amateur or processed at a lab. Color filter attachments were a non-intrusive method of introducing color to the projected image. The interactive factor also provided an element of

performance to the home movie experience. These filter attachments were advertised regularly in the amateur cine press throughout 1927-29, but the author has yet to find an extant example. There are some known examples of projectors with purpose-fitted color filters: Pathé 9.5mm and Keystone 16mm.

Lenticular



Fig. 3 Kodacolor box and Kodacolor filter (Chicago Film Archives);
Agfacolor filters (Leitz Photographica Auction)

The launch of Kodacolor in the United States in September 1928 was met with palpable joy by Amateur Cine League president Hiram Percy Maxim - “Kodacolor has made a dream come true” (Maxim, 1928, p. 567). In a lengthy and enthusiastic article, Maxim summarized the technological ingenuity of the lenticular process, and described the mesmerizing effect of seeing a person filmed in color - “the startling effect of seeing living, breathing flesh and blood” (Maxim, 1928, p. 615).

The Kodacolor film stock was black and white reversal containing miniscule lenses running the length of the film. When exposed through a tri-colored filter attached to the camera lens, and projected back through the filter attached to the projector, “natural color” was achieved. Although the process had its drawbacks – additional accessories, the necessity of bright lighting conditions, limited to Kodak cameras and projectors – it was broadly a success and was embraced by many keen amateurs.

Agfacolor 16mm used the lenticular process but with a slightly different tri-color filter design (note that the name Agfacolor was used for several different processes). The image in Fig. 3 is likely for a stills camera using lenticular film. While there are reports of Agfacolor lenticular film being demonstrated in Germany and Britain in 1931 and 1932, it is not known if it was ever manufactured for commercial sale.

Rotating color filter

Based on earlier processes available to professional filmmakers such as Kinemacolor and Biocolor, a number of attempts were made to replicate the principle of a rotating color filter for the amateur market.



Fig. 4 – Vitacolor advertisement (*Movie Makers*, May 1929, pp. 282-283)

Vitacolor was the most commercially successful of these. Demonstrations around the U.S. in 1928 and launched to the public the following year, the process used black and white negative stock exposed in the camera through a rotating red and green filter. After processing, a positive print was made, which was then projected through a rotating red and green filter attached to the projector. As with the lenticular process, due to the addition of the colored filter, brighter lighting conditions were necessary. There was also an issue with “fringing” – the separation of the red and green filters – particularly when the filmed subject was in motion. Despite this, the process was well-received by those who attended the demonstration screenings, even by those who had previously been skeptical about color. Herbert McKay declared Vitacolor to be superior to “old” Kinemacolor, and said “Every amateur owes it to himself to make films in natural color” (McKay, 1929, p. 228)

In Austria, Ukrainian-born, Josef Mroz, experimented with a similar process for 9.5mm. Comparable to Friese-Greene’s Biocolour, the process exposed panchromatic black and white stock through a rotating green and red filter, then after processing, the film’s alternate frames were colored red and green. As the color was applied directly to the film, there was no need for a rotating filter on the projector. The process was not made commercially available.

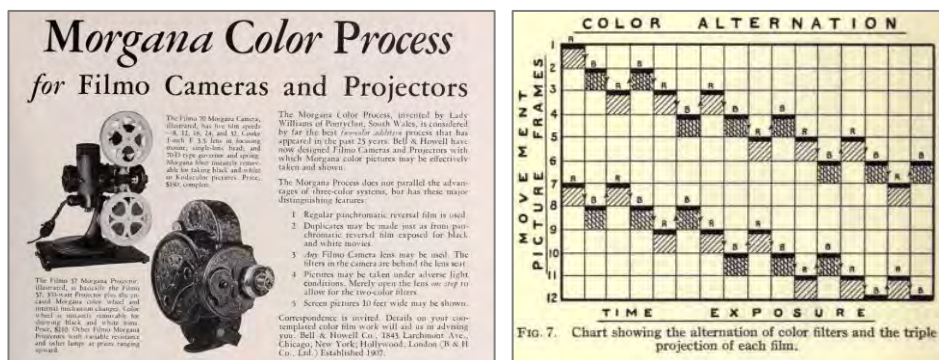


Fig. 5 – Morgana Color/Bell & Howell advertisement (*Movie Makers*, July 1932, p. 285); Color alternation chart (SMPE Journal, 1933, pp. 403-412)

Morgana Color refined the rotating red and green filter process by attempting to eliminate excessive flicker and fringing during projection. Co-inventors Lady Juliet Rhys-Williams and George Short, devised a complex projection mechanism that advanced the film two successive frames forward and one backward, which according to Bell & Howell employee, Joseph Dubray meant that, “... although

the film is running at a linear speed of 24 frames per second, 72 frames are alternating at the aperture during the same length of time, each picture frame being projected three times on the screen.” (Dubray, 1932, p. 410) The process was backed and promoted in 1932 by Bell & Howell for their Filmo cameras and projectors. The author has found references to a demonstration film made by Dubray of the 1933 Tournament of Roses, Pasadena, USA, and of Morgana Color used on a trip to Africa in 1933 by Compte de Janze, and has also located a few sample frames in the Theisen Film Frame Collection at the Seaver Center for Western History, Los Angeles. But despite these references and the B&H advertisement, it is unclear whether the equipment was ever sold commercially.

Integral Réseau – Dufaycolor



Fig. 6 – Advertisements for Dufaycolor movie film; Dufaycolor réseau
(*Amateur Cine World*, Sept 1934, p. 156; Dufaycolor Book, 1935; *Movie Makers*, June 1935, p. 232)

Launched in the United Kingdom in September 1934, Dufaycolor 16mm was the first color process available to amateurs that did not require additional accessories to produce the color. Drastically refined from Louis Dufay's original technique from the early 1900s, a complex mechanical process added a minute regular pattern of red, green, and blue dyes - the réseau - to the base of a black and white reversal film. The film ran through the camera with the base facing the subject so that light passed through the dyes before exposing the emulsion. After processing, the film ran through the projector with the emulsion facing the screen, so that the projector lamp passed through the colored base first. When viewed at an optimal distance, the pattern of the réseau was barely discernable. Because of its ease of use, and in spite of it requiring brighter lighting conditions, Dufaycolor enjoyed reasonable commercial success (in stills photography too). Its U.S. debut in spring/summer 1935, however, was overshadowed by Kodachrome, which was launched at the same time. Nevertheless, it remained on the amateur market until around 1950, with 9.5mm reels and cartridges also manufactured.

Conclusion

The impracticalities of accessories and slow film speed, as well as poor cost-effectiveness, meant that these early additive color processes were short-lived and achieved relatively low commercial success. With the arrival of Kodachrome in 1935, the path was set for subtractive processes to dominate the markets. However, the early additive processes should not be dismissed because of their inherent 'flaws', but instead their inventors' ingenuity and each process's unique characteristics and aesthetic qualities celebrated.

Bibliography

Dubray, J. (1933) 'The Morgana Color Process', *Journal of the Society of Motion Picture Engineers*, November, pp. 403-412

Maxim, H. (1928) 'Color Comes to the Amateur', *Movie Makers*, September, pp. 567-71; 614-17

McKay, H. (1926) 'The Amateur Kinematographer', *Photo Era*, 5 May, p.285

McKay, H. (1929) "Vitacolor", *Photo Era*, 4 April, p. 228

Oswald, C. (1928) 'The End of the Rainbow – Possibilities of Color Motion Photography for the Amateur', *Movie Makers*, January, pp.15; 56

s.n. (1929) 'Natural Color – Promise or Threat?', *Photo Era*, 3 September, p.171

Stull, W. (1933) 'Tinting and Toning 16mm Films', *American Cinematographer*, May, pp. 18; 32

Zingl, S. (2018) '91/2-mm barni film je tu!', *Kino!*, May, Retrieved 2019 <https://e-kino.si/clanki/9%c2%bd-mm-barvni-film-je-tu-barvna-senzacija-mrozovega-farbenfilma/>

The use of colour in early filmic images

Annamaria Poli

Università degli Studi di Milano-Bicocca

annamaria.poli@unimib.it

Abstract

From cinema's very origins, colour has always been a key feature, appearing in both the first moving pictures produced for entertainment with pre-cinema devices and early film. Images were initially colourised by applying colour directly to each individual frame, whether of paper, glass, or celluloid film (Mannoni and Pesenti Campagnoni, 2009). Over time, these colour images have come to bear inestimable value due to their unique status as the output of the most amazing technical and artistic experiment ever made.

Colour – produced using a variety of mediums from pigment to digital technologies – has fulfilled multiple roles throughout the history of cinema. For example, colour plays an important part in the narrative dimension of film by offering viewers an additional code for interpreting the content and space-time location of a given scene. Early colour productions include *Pauvre Pierrot* from 1892 and *Autour d'une Cabine* from 1894, both made by Émile Reynaud, the French pioneer of animated film. In the same period, leading early filmmakers, including the brothers Auguste and Louis Lumière, Georges Méliès, Thomas Alva Edison and the Pathé Frères, were among the first to make colour movies. These films require careful conservation, which is difficult to maintain over the long term. It has become crucial to digitize valuable early works as our conservation strategy going forward.

Keywords: early film, film colourised, stencil, coloured film conservation.

Introduction

Charles Émile Reynaud, the Frenchman who pioneered animation, created his first animated scenes in colour in 1892. Earlier, in 1876, he had invented the praxinoscope, a device based on the phénakistiscope and zoetrope, which could be used to play short animated sequences. (Rondolino, (2003); Tosi, 1984).

From 1892 to 1900, Reynaud worked hard to bring animated drawings to the public, using his invention, the *théâtre optique*, to project his famous “illuminated pantomimes” to audiences (Pesenti Campagnoni, 2007).



Fig. 1 - The “bright pantomimes” of Emile Reynaud at *Le théâtre optique*, Paris

Pauvre Pierrot from 1892 and *Autour d'une Cabine* from 1894 are two of Reynaud's animated films that have survived intact (Bazin, 1950). These two-minute sequences prove that motion-picture animation was “born in colour”, however the technology was not available at that early stage to shoot coloured images on a cellulose nitrate base. To overcome this issue, early filmmakers resorted to

colouring picture frames using a variety of techniques (Montanaro, 2005). The results in some cases were perceptually and visually stimulating, eliciting new expectations and increasingly more sophisticated visual interpretation skills.



Fig. 2, 3 - *Pauvre Pierrot* (1892) and *Autour d'une Cabine* (1894) by Charles Émile Reynaud

Early colour film from 1895 to 1910

Between 1895 and 1912, film was coloured via one of two techniques, which both involved applying chemical colour pigment, aniline dyes, to the emulsion on the film base. The first technique used a paintbrush or stencil (*pochoir*) to add touches of colour pigment frame by frame, a method that was extremely labour intensive because it was hand done by a small number of individuals, usually women (Figs. 4 and 5). The other technique entailed adding colour to a full roll of film, or to film sequences, via the imbibition of a monochromatic tint.



Fig. 4, 5 – Examples of film colourization techniques from 1895. (Source: *Les premiers pas du cinema, Paris 2004*)

Annabelle Serpentine Dance, produced by William K.L. Dickson and Thomas Edison in 1895, was the first hand-coloured early film. The subject of this film is the choreography of the serpentine dance performed by the famous American dancer, Annabelle Moore (Fig. 6). Some years later, in 1903, a key early film, *The Great Train Robbery*, was produced at the Edison Manufacturing Company under the direction of Edwin S. Porter (Figs.7,8). It is one of the rare early colour films to have survived to the present day. In this case, the aniline dyes were applied to the emulsion using a combination of the two colourization techniques described above (Montanaro, 2005).



Fig. 6 - *Annabelle Serpentine Dance*, (1895) by W.K.L. Dickson and T.A. Edison, the first hand-coloured early film.

Fig. 7, 8 - *The Great Train Robbery* (1903) by Edwin S. Porter

The Lumière Brothers also experimented with colourization: in 1897, they made the early film *Danse Serpentine*, which is listed as No. 765 in their catalogue. An unknown cameraman shot the scene in Italy, and the colour was applied subsequently using the paintbrush technique (AA.VV., 2016). This

early film is perceptually impressive thanks to the choreographic movements of the dancer: she is constantly on the move, twirling the long sleeves of her silk dress, while the colourization endows a surprising gradient effect on her every movement.



Fig. 9 - *Danse Serpentine* (1897) by Lumière Brother

In 1897, Georges Méliès also introduced colourization into his film production. His first colour film was *Le Château Hanté*. Lasting 50 seconds, this film is set in the hall of a castle. The lighting is gloomy, but the viewer can make out the protagonist, who is dressed in red. In 1899, Méliès produced a second early colour film *Cendrillon*, which was inspired by Charles Perrault's Cinderella and indeed was the first ever on-screen representation of a fairy tale. Méliès used a fixed-shot technique and the sequence consists of 20 tableaux. The first shots feature profilmic elements that were coloured using the paintbrush technique. In 1900, Méliès made *Jeanne d'Arc* and in 1902 the famous *Le Voyage dans la Lune* based on a science fiction novel by Jules Verne. The latter work depicts astronomers travelling from Earth to the Moon and back. *Le Voyage dans la Lune* is the most influential film of the history of cinema. Only two copies of it have survived, a black and white and a colour (paintbrush technique) version. Georges Méliès went on to produce other hand-coloured films: *Le Royaume des Fées* in 1903 and in 1904 *Le Barbier de Séville*, *Le rêve du Rajah* and the *Voyage à travers l'impossible* based on



Fig. 10, 11, 12, 13 – The early coloured films of Georges Méliès from 1897 to 1902:
Le Château Hanté, *Cendrillon*, *Jeanne d'Arc*, *Le Voyage dans la Lune*,



Fig. 14, 15, 16 – Georges Méliès early film coloured from 1904 to 1909: *Le Royaume des Fées*, *Voyage à travers l'impossible*.

another of Jules Verne's science fiction novels. These were followed by *Le Palais des mille et une nuits* in 1905 and *Le Papillon Fantastique*, *Le Locataire Diabolique*, and *Les Illusions Fantaisistes* in 1909 (Mannoni and Malthête, 2008).

In France in 1901, Ferdinand Zecca, a filmmaker at Pathé Frères Film Company made *Ali Baba et les quarante voleurs* in black and white; in 1905, a colourized version of this work (Fig. 17) was produced by adding pigment colours to the film stock using a paintbrush or pad. Scene changes were planned as a function of the flow of the story. Each of the seven scenes was introduced by a title and the transition from one scene to the next was flagged by using narrative text or dialogue in the title, for example: "Open Sesame!" Set design and composition were complex, perspective was used to create an illusion of depth, and mechanical movement was introduced for some elements of the set. The film was

colourized using a restricted range of chromatic colours. Magenta, yellow, and cyan were those most frequently used, with light green and red appearing more rarely. In 1906, Pathé Frères produced *Aladin ou la lampe merveilleuse* (Fig. 18), an early film with spectacularly rich sets. Colourization was used to further enhance the expressiveness of the scenes and amplify their emotional impact on the viewer.



Fig. 17,18,19 – Pathé Frères productions between 1905 and 1908: *Ali Baba et les quarante voleurs*, *Aladin ou la lampe merveilleuse*, *Magic Bricks*.

The Pathé Frères film company specialized in the colourization of early films via the direct application of colour pigment onto the film stock using the paintbrush technique. In addition to the examples already cited, another key work is an early film with rich special effects entitled *Magic Bricks*, which was produced in 1908 under the direction of Gaston Velle (Fig. 19).

In 1912, the first colour feature film was produced: *Le Miracle* directed by Michel Carré.

As time went on, new techniques of film colorization were developed, including Kinemacolor and George Eastman's Technicolor.

The role of colour in early film

Historically, early filmmakers used a variety of film bases: glass, paper and a plastic medium known as cellulose nitrate. These materials were tinted using different colorization techniques, such as the subtractive method involving the imbibition of chemical pigments in a monochromatic aniline solution or the use of paintbrushes and stencil to obtain a partial colour effect (Yumibe, 2012).

The partial or total colourization of scenes enabled colour to play a number of different roles.

Tinting a series of shots with the same colour to form a film sequence fulfilled a dual – realistic and/or symbolic – function: for example, blue was used to represent the night and green to depict landscapes while, more rarely, the colour red was deployed to represent fires, disasters, or armed revolutions, thus additionally acting as a symbolic and "signifying" element.

Thus, from early on, colour contributed to the narrative dimension of film, by offering viewers an additional code for interpreting the story and situating a given scene in space and time. Another way in which colour has been used to express space-time relations is as a marker of the passage of time between past, present and future. For example, in flashbacks, the transition from one time period to another is usually marked by a change of colour scheme. Another contribution of colour in early film was its perceptual power to encode the expression of emotion. In this regard, Michelangelo Antonioni claimed that: "[...] There is no such thing as colour in the absolute. It is always a relationship. A relationship between the object and the observer (or rather the physical state of the observer), between the object and the direction of the rays illuminating it, between the material the object is made of and the psychological state of the observer, in the sense that each influences the other. That is to say, the object with its colour makes a particular impression on the observer, who at the same time sees in that object the colour that they are interested in or feel like seeing at that particular moment"(Di Carlo, 1964).

Colour is thus an integral component of human thinking and experience that is perceived at, at least three, different levels: physical, psychological, and physiological.

In film, the artistic value of colour images is conferred by the colours themselves, which change in tandem with the movement of the images and bear the expressive force of unfolding chromatic "experience". In his writings on colour, Sergej Ejzenšteinhad devoted considerable time to exploring the domain of so-called "absolute relations", that is to say, the way in which particular colours are associated with particular emotions, to the extent that he defined colour as experimenting with

different sensory correspondences. Later Bèla Baláz revisited Ejzenštein's work, emphasizing the expressive value of colour in moving pictures: "The painter can paint the redness of a face, but cannot paint a face that suddenly goes from pale to purple". Hence, the artistic value of cinematographic colour images lies in the moving colours themselves and in their capacity to generate emotions in the spectator.

Conservation of Early Film

The first plastic base used in film production, beginning in 1895, was cellulose nitrate. Pioneering filmmakers used this material until Eastman Kodak replaced it with a more modern form of nitrate. Most early films, and many silent movies, were shot on a cellulose nitrate base, a 35 mm plastic roll treated with nitric acid. Cellulose nitrate is a fibre that is extremely difficult and time-consuming to conserve, given that it is easily damaged by light, air pollution, and high temperatures. These factors impeded the successful conservation of early films and silent movies; hence, many early filmic works and other films made before 1950 have been lost to us forever (Edmondson and Schou, 1984).

Restoration and conservation via digitalization

Conserving our motion picture heritage is of key importance to humanity. In 1980, UNESCO recognized film as an integral part of world cultural heritage that should be conserved in a form that is as close to the original as possible so that it may be experienced by future generations. In 2002, UNESCO declared *Le voyage dans la lune* by Georges Méliès (both black and white and colour versions), on the first centenary of its production, a World Heritage Site.

Thanks to digital technologies, historical knowledge has acquired a new dimension: for some years new archives for research have taken shape: the digitization by scanning high-resolution images using high-spec computers will ensure that this filmic heritage is restored, conserved, and remembered going forward (De Robbio, 2007).

Conclusion

Colour has played and continues to play multiple roles in filmic narratives from the analogical to the digital movie era. The present historical summary of colour films from the period spanning the late nineteenth and early twentieth centuries has emphasized the extraordinary role of colour in rare early films made by the pioneers of cinema. The direct application of chemical colour pigment made the cellulose nitrate base then in use even more fragile and delicate, although this material in any case demands a conservation strategy that has historically proven difficult to implement. Hence, the urgent need for digitization techniques enabling us to make digital copies of early films. Digital technologies will ensure that we can continue to conserve the "original" works, despite the progressive phasing out of analogue technologies. In parallel, digitisation will enable the large-scale dissemination of early filmic contents over the Internet, offering open access to anyone who is interested in experiencing and learning about them.

UNESCO has recognized that movies are an integral part of world cultural heritage that is vital to preserve for future generations. Digitalization techniques are key to restoring and conserving the "original" works. The digitization of early films will also ensure that they are widely disseminated, while greater knowledge and awareness of their existence will in turn contribute significantly to preserving their memory.

Bibliography

AA.VV. (2016) *Lumière! L'invenzione del Cinematografo*. Cineteca Bologna, Bologna.

Bazin, A. (1950) 'Invenzione e mito del cinema', *Sequenze*, n. 8, Parma, pp 09-16.

De Robbio, A. (2007) *Archivi aperti e comunicazione scientifica*. Vol. 4, ClioPress, Napoli.

Di Carlo, C. (1964) *Il deserto rosso. Dal soggetto al film*. Cappelli, Bologna.

Edmondson, R. and Schou, H. (1984) 'L'ultimatum dei nitrati', *Il corriere dell'UNESCO: una finestra aperta sul mondo*, XXXVII (8) 10-11, Estratto 28 mese di aprile 2020.

Mannoni, L. and Malthête, J. (2008) *L'œuvre de Georges Méliès*. Éditions de la Martinière, Paris.

Mannoni, L. and Pesenti Campagnoni, D. (2009) *Lanterne magique et film peint, 400 ans de cinéma*. Éditions de la Martinière, Paris.

Montanaro, C. (2005) *Dall'argento al pixel*. Le Mani, Genova.

Pesenti Campagnoni, D. (2007) *Quando il cinema non c'era*. Utet, Torino.

Yumibe, J. (2012) *Moving Color: Early Film, Mass Culture, Modernism*. Rutgers University Press US: New Brunswick.

Rondolino, G. (2003) *Storia del cinema di animazione*. Utet, Torino.

Tosi, V. (1984) *Il cinema prima di Lumière*. ERI, Torino.

The origin of the colours of the first colour photograph: a predominant absorption phenomenon

Victor de Seauve¹, Marie-Angélique Languille¹, Bertrand Lavédrine¹

¹Centre de Recherche sur la Conservation, MNHN-CNRS-Ministère de la Culture
Contact: Marie-Angélique Languille, marie-angelique.languille@mnhn.fr

Keywords: first colour photograph, Edmond Becquerel, UV-Vis spectroscopy, silver chloride, silver nanoparticles, plasmons

Introduction

Although the first popular colour photographic processes only came into being at the dawn of the 20th century and used the principles of additive and then, later on, subtractive processes were introduced (Lavédrine, 2020), the 19th century saw numerous attempts to find a solution to the problem posed by François Arago (1786 - 1853) of discovering "a substance which red rays would colour red, which yellow rays would colour yellow, on which blue rays would leave a blue imprint etc., etc." (Arago, 1839). In 1848, Alexandre Edmond Becquerel (French physicist, 1820 - 1891) sent a paper to the Académie des Sciences in Paris providing a solution to this problem, thus introducing the first colour photograph. He developed a printing-out positive process to produce colour photographs onto sensitized silver plates, the "photochromatic images" (Becquerel, 1867). Among the first images he obtained, he recorded the solar spectrum by directly projecting it onto the sensitized plate (Fig. 1). At least, two examples of this solar spectrum image are kept in museum collections, one at the Musée Nicéphore Niépce (Châlon-sur-Saône, France) and the other one at Musée des arts et métiers (CNAM, Paris). This very first colour photographic process did not see any practical development because of its low sensitivity that implies long exposure times and because it was not possible to fix those images that slowly fade while exhibited. Photochromatic images are still light sensitive and have to be kept in the dark. Becquerel wrote he had not yet "been able to arrest the subsequent action of diffused light which gradually destroys the images" (Becquerel, 1854). Becquerel abandoned research on this subject in 1854. Abel Niépce de Saint Victor (1805 - 1870) tried, without success, to find a method of fixing or at least stabilising these images.

There was a long debate in the second half of the 19th century about the origin of the colours of the photographs produced by Becquerel. Although only a small number of photochromatic images have survived till today, these images have never ceased to intrigue with regard to the nature of the sensitive layer and the origin of their colours. For Becquerel, they were "outside of all that is known about optics" (Becquerel, 1848). The proponents of a pigmentary origin of colour, i.e. directly linked to the chemical composition of the coloured layer, opposed those of an interferential origin, linked to a layer of given thickness or periodically organised. The invention in 1891 by Gabriel Lippmann of an interferential photography process reactivated this debate, even though neither Lippmann, Edmond nor his son Henri Becquerel believed in an interferential origin (Becquerel, 1892).

In this work we have tried to determine the phenomenon at the origin of these colours in the photochromatic plates by characterizing the silver deposit in replicas made in the laboratory.

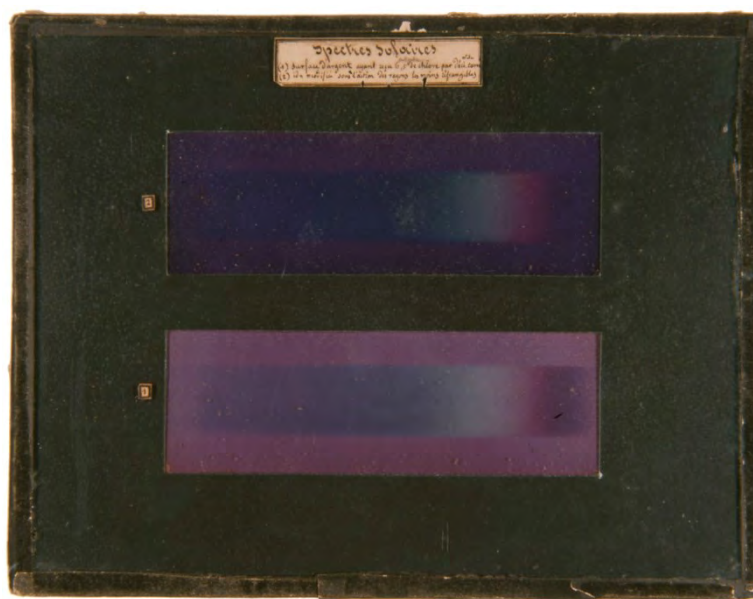


Fig. 1 - Becquerel, Edmond. Spectres solaires. 1848. Photochromatic images. Musée Nicéphore Niépce, Chalon-sur-Saône. Both solar spectra were obtained on electrochemically prepared plates, the bottom one was preexposed to infrared.

Experimental approach

It is these hypotheses of pigmentary origin and interferential origin widely spread in the literature, including in the 21st century, that we have reinterrogated with our experimental approach. Because of their high sensitivity to light, we did not work on Becquerel's originals. We reproduced the process in the laboratory following the writings of Becquerel and we prepared sets of coloured samples for analysis (de Seauve, 2018; de Seauve *et al.*, 2020a). This has been challenging as the analyses involve photonic or electronic probes which themselves can alter the image. We had to implement a methodology capable of monitoring and mitigating all the effects of the beams used to characterize the optical, electronic, morphological and structural properties of the photographic image. Our approach was to assess differences between the coloured samples in chemical composition and morphology in order to determine what distinguishes them, and eventually to deduce the origin of the colours.

The direct printing-out positive colour images are prepared in a very simple way that requires no photographic development: a polished silver plate is sensitized by a chlorine solution and then exposed to the light in the camera.

UV-Vis characterization of sensitized and coloured samples

We measured a set of sensitised model samples using UV-visible reflection and transmission spectroscopy so that the absorbance could thus be calculated. We exposed the samples to visible radiation and then measured the coloured samples again. The calculated absorbance intensity is plotted as a function of the wavelength on Fig. 2. The blue spectrum corresponds to a blue coloured layer following the exposure of light through a blue filter whose bandwidth is centred at 402 nm. Similarly, the red spectrum corresponds to a red layer after exposure to light through a red filter with a bandwidth centred at 677 nm and the yellow spectrum corresponds to a yellow sample, etc.

The spectra display a long absorption tail in the visible region, a steep edge in the violet region at 404 nm, and a second edge in the ultraviolet region at 255 nm; these spectra are comparable to that of silver chloride in the ultraviolet region, but they also show a broad absorption band in the visible region, centered on 500 nm. According to the literature, this band is characteristic of the presence of silver nanoparticles and it is broad because of an inhomogeneous set of nanoparticles. We therefore suspected that the sensitive layer and the coloured layers consisted of silver chloride crystals and metallic silver in the form of nanoparticles. And we confirmed this by multiple elementary surface and volume analyses (de Seauve, 2018; de Seauve *et al.*, 2020b).

In addition to these three characteristics, for all wavelengths above 473 nm, we notice a decrease in absorbance exactly at the exposure wavelength, and at longer wavelengths (584, 633 and 677 nm), this decrease is so marked that it results in a local minimum of absorbance, an “absorption hole”.

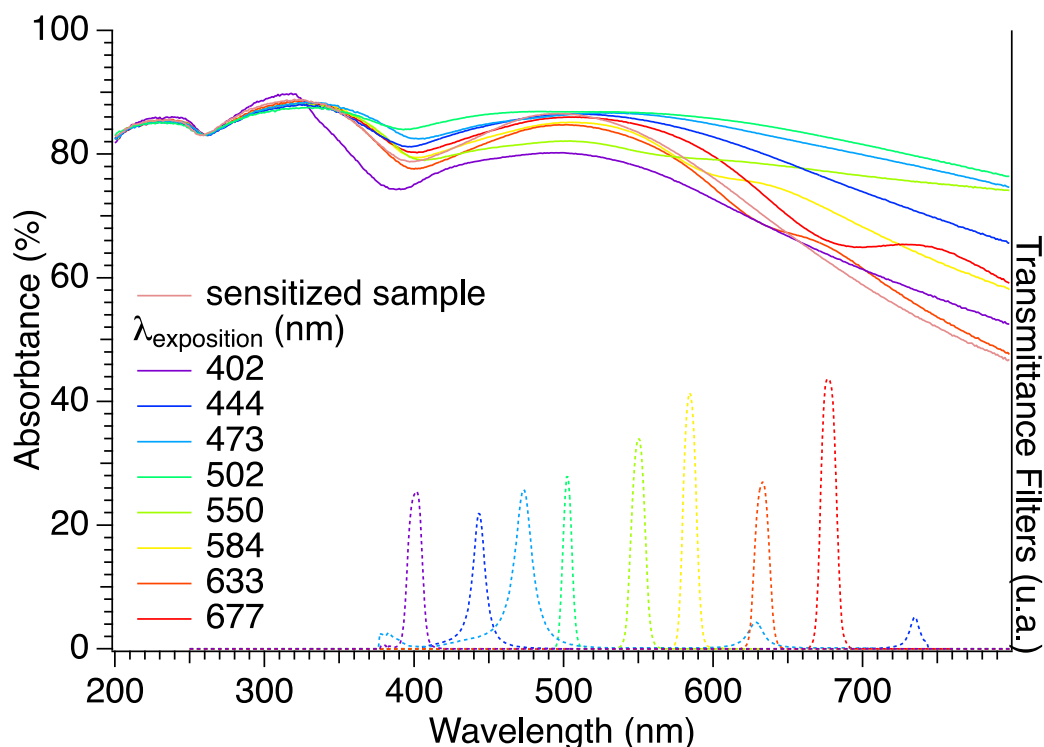


Fig. 2 - Absorbance after sensitised model samples exposure to coloured light. The transmittances of the filters used for the exposure step are plotted as dashed lines.

So, these UV-Vis spectra show that absorption dominates the optical characteristics of these coloured samples and is the major responsible for the colours of the plates. The visible absorption characteristic of the exposure wavelength contributes to invalidate the interference hypothesis.

These photo-induced spectral changes observed during the exposure step, should reflect morphological variations of the constituents of the coloured layers.

Chemical and structural characterization

We have thus established that photochromatic images are composed of silver chloride and metallic silver. Moreover, this chemical composition does not vary according to the colours. The morphology, i.e. the relative organisation of silver chloride and silver within the layers, was characterised in planar and cross-sectional views by electron microscopy (scanning and transmission) combined with electron and X-ray spectroscopy. The results of this first large-scale experimental investigation of the sensitive and coloured layers of photochromatic images show that they consist of silver nanoparticles of 10 to 150 nm dispersed in a matrix of micrometric silver chloride grains. These dispersions of silver nanoparticles of varying sizes, shapes and locations are responsible for the visible absorption band of the sensitive and coloured layers (de Seauve, 2018; de Seauve *et al.*, 2020b).

Conclusion

These sets of nanoparticles in the coloured samples are the only characteristic colour mark we have found. We postulate that the decrease in absorption of the coloured layers in the visible, located at the wavelength to which they were exposed, is due to a lack of nanoparticles of a specific shape, size and location. These "missing" nanoparticles would be those which, in the original sensitive plate, absorbed in the wavelengths range of exposure. This is why we believe that these particular absorption properties - known as plasmonic - specific to metallic silver nanoparticles included here

in a silver chloride matrix, are at the origin of the colours of photochromatic images. In disagreement with the majority of the works published until now, we thus formulate a plasmonic hypothesis on the origin of the colours of the first colour photographs. The origin of the colours of photochromatic images explains their great sensitivity to diffuse light and the irremediable loss of colours if they are not preserved in the dark.

Bibliography

Arago, F. (1839) 'Séance du 11 mars 1839', *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, 8, p. 362.

Becquerel, E. (1848) 'De l'image photographique colorée du spectre solaire', *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, 26, pp. 181–183.

Becquerel, E. (1854) 'Nouvelles recherches sur les impressions colorées produites lors de l'action chimique de la lumière', *Annales de chimie et de physique*, 42, pp. 81–106.

Becquerel, E. (1867) 'Chapitre IV. Reproduction des couleurs par l'action de la lumière'. In *La lumière, ses causes et ses effets. Tome second : Effets de la lumière*. Livre III : Photographie, 209–34. Paris: F. Didot frères, fils et Cie, 1867. <http://gallica.bnf.fr/ark:/12148/bpt6k90369m>. [Online; accessed 01-Jun.-2021]

Becquerel, H. (1892) *Les Expériences de M. Edmond Becquerel sur les actions chimiques de la lumière et l'héliochromie: Conférence du 20 mars 1892*. Paris, France: Gauthier-Villars.

Lavédrine, B. (2020) 'Painting with Light. Between Art and Science, the Dawn of Colour Photography in the 19th Century', in *Impressionism between art and science. Light through the prism of Augustin Fresnel (from 1790 to 1900)*. Paris: Hermann, pp. 114–197.

de Seauve, V. (2018) *A l'origine des couleurs des images photochromatiques d'Edmond Becquerel : étude par spectroscopies et microscopies électroniques*. Thèse de doctorat. École Normale Supérieure.

de Seauve, V., Languille, M.-A., Vanpeene, S., *et al.* (2020) 'Replication and study of the colouration of Edmond Becquerel's photochromatic images', *Journal of Cultural Heritage*, 45, pp. 114–121. doi: <https://doi.org/10.1016/j.culher.2020.02.016>.

de Seauve, V., Languille, M.-A., Kociak, M., *et al.* (2020) 'Spectroscopies and Electron Microscopies Unravel the Origin of the First Colour Photographs', *Angewandte Chemie*, 132(23), pp. 9198–9204. doi: [10.1002/ange.202001241](https://doi.org/10.1002/ange.202001241).

Green and Greener Solvents in Photographic Conservation

Barbara Cattaneo¹, Giulia Fraticelli²

¹ Opificio delle Pietre Dure, Florence, Italy, and IFAC-CNR, Florence, Italy

² Independent conservator, OPD collaborator

Contact: Barbara Cattaneo, barbara.cattaneo@beniculturali.it

Abstract

Green chemistry and sustainability are known to be the keywords for the next era of the conservation of cultural heritage. Since the 1980s, environmental issues have changed the prospects for market orientation, both in the production of photographic and film materials.

This paper aims to provide information on an ongoing research that has been carried out on the application of ‘green’ and ‘greener’ solvents for the removal of stain and adhesives. Diethyl carbonate, limonene, ethyl lactate, and eucalyptus oil were evaluated when applied in free form and solvent gels. Before and after the treatments scientific analysis was carried out to determine their effectiveness and the persistence of residues.

Keywords: green chemistry, green solvent, cleaning, photographic conservation.

Introduction

Solvent based cleaning is part of the daily routine of a conservation laboratory, therefore sustainability and research into the efficiency and effectiveness of green and greener materials are now mandatory. Since the 1980s, environmental issues changed the market orientation perspectives, both in the production of photographic materials and films. The discontinuing of Polaroids, also due to toxicity of its components, is just one example. Almost the same happened in the photographic conservation fields, where solvents have been widely used for routine operation, mainly for superficial cleaning, like fingerprints removal and PST removal. One example is 1,1,1-Trichloroethane, a low polarity solvent commonly used to clean photographic films until it was banned by the Montreal Protocol of 1996, due to its contribution to ozone depletion.

New restrictions and regulation, in particular the REACH processes (EC 1907/2006), which aim to improve the protection of human health and the environment, have led to a more in-depth study and to a new interest in green solvents. To be considered ‘green’, solvents must accomplish with a list of principles that involve human, animal and environmental safety, energy saving during the production cycle and waste reduction. Some of the solvents that do not meet all the requirements, but only a few of them, can still be considered ‘greener’ and may be an option when dealing with photographic objects. The current ethics of sustainability, promoted by the most important International organization such as ICCROM, UNESCO, ICOM, aims to achieve the same objectives, for example by implementing preventive conservation and balancing economy with environmentally friendly practices in museums. [UNESCO Green Chemistry] The aim of our ongoing research is to raise the awareness of photo conservators on environmental issues, and improve the preparation of the next generation of colleagues. For this reason, the students in their third year of the MA in Conservation and Restoration held at the Opificio delle Pietre Dure (Alessia Bianchi, Selene Chersicla, Giorgia Mori, Lavinia Nasoni and Matilde Ticci) were involved in the research. The students carried out tests on the methods of application and effectiveness of the four chosen solvents: Diethyl carbonate (DEC) (Ferrari et al. 2018; Mirabile et al. 2020), ethyl lactate (EL) (Pereira et al. 2011; Kua et al., 2016; Dolzhenko, 2020), limonene (*Li*) (Chemat et al. 2012; Ciriminna et al. 2014), and eucalyptus oil

(*EuO*) (Chemat, 2014). Chosen among others, microscopy, FTIR in reflectance and ATR mode were used to evaluate the results (Rosi et al. 2019).

The solvents were chosen after literature and experiences carried out in other conservation fields (Aparacio and Alcade 2009; Ferrari et al., 2018; Prati, et al., 2019). For these preliminary tests, Eucalyptus Globulus from the organic farm Flora s.r.l. (Lorenzana, Pisa) was chosen, thanks to the contact received from the colleagues from L'Immagine Ritrovata, Film Restoration Laboratory in Bologna. Planning a further study, a special batch of chemotyped oil prepared by the same laboratory will be researched.

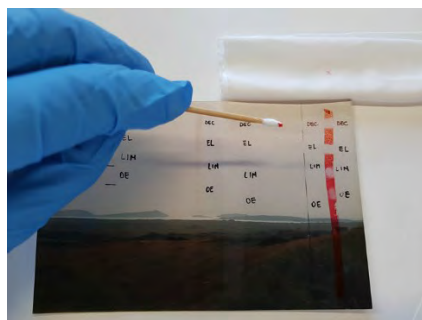


Fig. 1 Solvent applied with a cotton swab

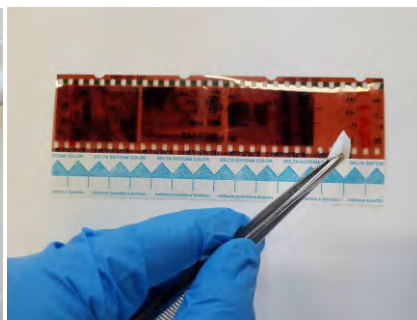


Fig. 2 Solvent applied with PU Sponge

Materials and Methods

One of the most important aspects, when developing cleaning methods using innovative solvents, is the evaluation of the effect that the solvent can produce on the substrate. To investigate this aspect, tests were carried out on photographic films and papers from 1978 to 1998. Each student received 4 chromogenic photographic papers (Kodak paper, Agfa, Konica Longlife 100, Fujicolor paper) and 2 chromogenic negatives (Kodak Gold 100, Agfa HDC 100). On each sample, a red permanent marker (Powerline 1100), a black ballpoint pen (Bic Cristal), a commercial gum arabic and PVA were applied in lines, recto and verso. The students were then asked to try to remove the colours and adhesives with DEC, EL, *Li*, and *EuO* through different methods: using a cotton swab (fig. 1), brush, PU sponges (fig. 2), microfiber cloth, organogels loaded with DEC. They were also asked to individually and creatively organize their time and data collection.



Fig. 3 Contact sheets showing a different degree of deterioration

In addition, 2 professional (unidentified) photographic papers showing a different degree of colour deterioration (fig. 3), one professional reversal film (Fujichrome Velvia 50 Professional) and one colour negative film (Kodak Gold 100) were analysed before and after treatments (FTIR in reflectance and ATR mode, Dinolite microscopy), in order to verify if any depolymerization would occur. On these samples the solvents were rubbed with a cotton swab for 5 seconds, air dried for the next 5 seconds, then dried with a microfiber cloth.

Spectra were recorded both by reflection and ATR measurements using the ALPHA Brucker spectrometer (OPUS software) with spectral range 400-7000 cm⁻¹, resolution 4 cm⁻¹. Reflectance measurements (100 scans) were performed with a background on gold and a measurement area of 4 mm diameter.

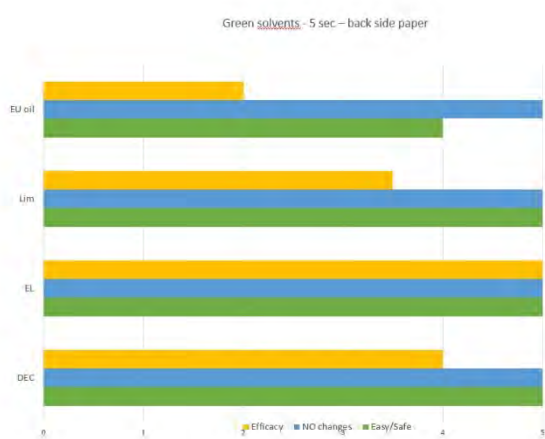


Fig. 4 Evaluation of the cleaning on the back side - paper

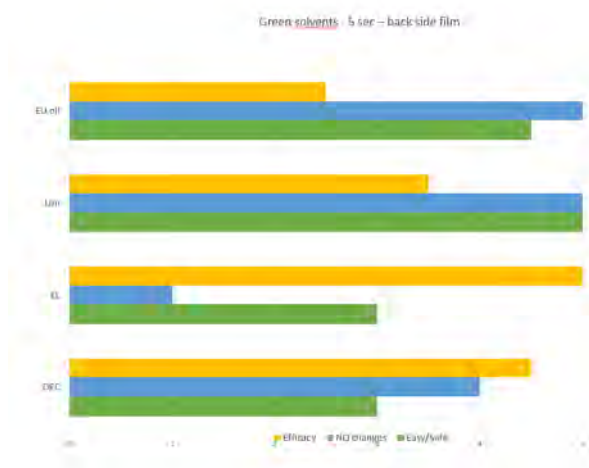


Fig. 5 Evaluation of the cleaning on the back side - film

Results and discussion

The final evaluation was influenced by three factors: the solvent was easy and safe to use, it did not change the surface after treatment, it was effective in removing stain/adhesives. EL proved to be the fastest and safest for the removal of marker and pen, it helped to swell the PVA (then mechanically removed) on the emulsion side of all samples and on paper sides (less than 10 seconds) (fig. 4), especially if applied with a PU sponge, but EL cannot be used on the back of the films, as it dissolves the cellulose triacetate (fig. 5). DEC performed well, although some shades of the marker and pen remained in place. The Organogel loaded with DEC failed to fully solubilize the colours, but it did help swell and facilitate the mechanical removal of PVA. Some halos remained, due to residues of the medium and the solvents. DEC dissolves the triacetate after 15 sec. application, therefore, only a maximum of 5 sec. can be considered safe. Limonene and Eucalyptus Oil have a lower solvent power. *EuO* leaves residues after a 10 seconds application when air dried. Halos can be reduced by blotting the solvent with a microfiber cloth. Gum arabic, being mainly water-soluble, could not be removed.

Microscopy observation showed that no changes or minimal changes occurred after treatments, except for EL and DEC.

FTIR analyses need a wider discussion. As for the sample of Kodak Gold film, the treatment in the ATR analyses with the four solvents did not reveal any alteration on the emulsion side, whereas the reflection analysis showed very limited variations in the spectra. However, variations are hardly attributable exclusively to the treatment itself. As for the base side, some surface modifications were clearly visible, but the ATR and reflection spectra of all areas, including the altered ones, show limited variations compared to the untreated film base. Changes in the intensity of some peaks are observed, however a further experimental investigation is required in order to attribute them to a polymer alteration phenomena.

The ATR measurements carried out on the deteriorated RC paper, showing the typical colour balance alteration, did not show significant changes in the spectral trend, whereas on the verso of the RC paper in good condition, a very slight variation in the spectrum appeared. The change can be related to the treatment performed with DEC. However, the analysis in reflection shows similar spectral profiles. The other solvent treated areas show spectra that are completely superimposable to those obtained before treatment, both in ATR and reflection.

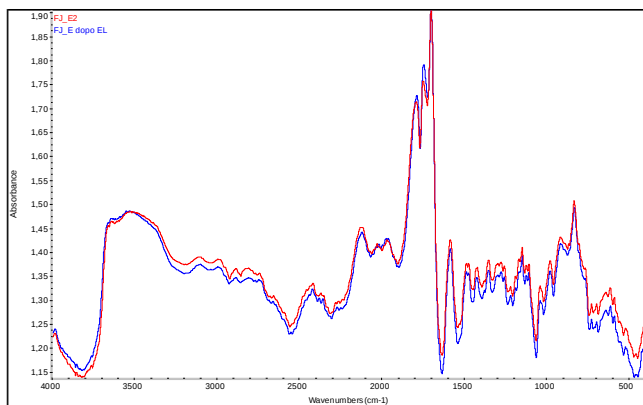


Fig. 6 FTIR ATR Analysis of the Fujifilm base (in red, before treatment)

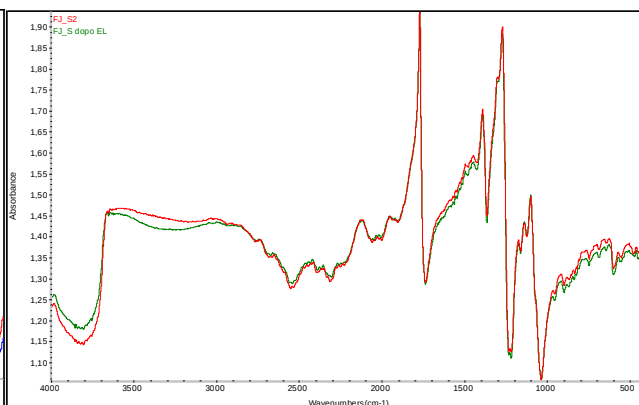


Fig. 7 FTIR in reflection of the Fujifilm base (in red, before treatment)

Finally, the analysis on the emulsion side of the Fuji film shows a slight variation in the intensity of the peaks both in the ATR analysis and in reflection. Also, the ATR analysis of the film base shows some changes of the peak intensities (fig. 6), which are, however, less evident in reflection (fig. 7). Also in this case, the registered changes can be related to the different treatments only through further experimental investigations.

Conclusion

Green solvents can be considered as a valid alternative to the traditional solvents used in the field of photographic conservation. DEC, EL, *Li* and *EuO* proved to be safe on the gelatine emulsion, and on the paper substrate. Although no changes were detected after treatments under the microscope, the risk of colours shifting need to be further investigated.

EL cannot be used on cellulose triacetate, as it visibly changes the surface, although FTIR analysis did not clearly detect the change. DEC effects the surface of the film base only when the treatment is prolonged. Further investigation is needed in order to attribute the very slight changes detected with the FTIR analysis.

The solvents tested during this research can be used as an alternative to Ethanol, which can be considered as a green solvent, and which is widely used in the conservation field. In some countries, though, Ethanol is extremely expensive or it is discouraged due to moral or religious reasons.

Water can be considered as the greenest solvent, but for conservation purposes it is necessary to use demineralized or distilled water, and thus the energy involved in the process needs to be taken into account.

Credits

The authors wish to thank Claudia Napoli (OPD), Maura Pischedda (Immagine Ritrovata), Andrea Cagnini (OPD Scientific laboratory), Sandra Rossi, Letizia Montalbano and Marco Ciatti (OPD).

Bibliography

Aparicio, S. and Alcalde, R. (2009) 'The green solvent ethyl lactate: an experimental and theoretical characterization', *Green Chemistry*, 11(1), pp. 65–78. doi: 10.1039/B811909K.

Chemat, F. (2014) *Essential oils as reagents in green chemistry*. Springer.

Chemat, S., Tomao, V. and Chemat, F. (2012) 'Limonene as green solvent for extraction of natural products', in *Green Solvents I*. Springer, pp. 175–186.

Ciriminna, R. et al. (2014) 'Limonene: a versatile chemical of the bioeconomy', *Chemical Communications*, 50(97), pp. 15288–15296.

Dolzhenko, A. V. (2020) 'Ethyl lactate and its aqueous solutions as sustainable media for organic synthesis', *Sustainable Chemistry and Pharmacy*, 18, p. 100322. doi: 10.1016/j.scp.2020.100322.

Ferrari, P. et al. (2018) 'Alkyl carbonate solvents confined in poly (ethyl methacrylate) organogels for the removal of pressure sensitive tapes (PSTs) from contemporary drawings', *Journal of Cultural Heritage*, 34, pp. 227–236. doi: 10.1016/j.culher.2018.05.009.

Kua, Y. L. et al. (2016) 'Ethyl lactate as a potential green solvent to extract hydrophilic (polar) and lipophilic (non-polar) phytonutrients simultaneously from fruit and vegetable by-products', *Sustainable Chemistry and Pharmacy*, 4, pp. 21–31.

Mirabile, A. et al. (2020) 'Innovative methods for the removal, and occasionally care, of pressure sensitive adhesive tapes from contemporary drawings', *Heritage Science*, 8, pp. 1–16.

Pereira, C. S., Silva, V. M. and Rodrigues, A. E. (2011) 'Ethyl lactate as a solvent: properties, applications and production processes—a review', *Green Chemistry*, 13(10), pp. 2658–2671.

Prati, S. et al. (2019) 'Cleaning oil paintings: NMR relaxometry and SPME to evaluate the effects of green solvents and innovative green gels', *New Journal of Chemistry*, 43(21), pp. 8229–8238. doi:10.1039/C9NJ00186G.

Rosi, F. et al. (2019) 'Recent trends in the application of Fourier Transform Infrared (FT-IR) spectroscopy in Heritage Science: from micro- to non-invasive FT-IR', *Physical Sciences Reviews*, 4(11). doi: 10.1515/psr-2018-0006.

UNESCO <http://www.unesco.org/new/en/natural-sciences/science-technology/basic-sciences/chemistry/green-chemistry-for-life/twelve-principles-of-green-chemistry/>

See also <https://www.sustainabilityinconservation.com/>

Preserving Color and Preserving Knowledge. Notes on Digitization and Restoration of Color in Film

Daniela Currò¹, Marco Pagni Fontebuoni²

¹Ca' Foscari University of Venice

²FILM Ferrania – Movie and Sound laboratory, Florence

Contacts: Daniela Currò, curro.daniela@gmail.com;

Marco Pagni Fontebuoni, marco.pagni.fontebuoni@gmail.com

Abstract

With the transition to digital cinema, moving images created on film are being digitized to guarantee wide access to film heritage through digital projection and distribution. The digital translation of an analog work, especially for what concerns reproduction of colors, is however quite problematic and needs to be guided and controlled by highly competent technicians and curators. The authors argue that, in order to accurately represent legacy color technologies, it is key to preserve knowledge and expertise at three levels: knowledge of historical color processes, knowledge of analog laboratory practices, and the know-how related to a wide array of analog and digital equipment.

Introduction

Cinema was originally conceived as a system to project on the big screen of cinema theaters positive film copies created by printing from a film negative. With the transition to D-Cinema, moving images created on film are being digitized in order to guarantee wide access to film heritage, with consumption progressively shifting from cinema projection to online access and streaming services. However, the digital emulation of a cinematographic work born on film cannot often stand the comparison with a film print created with a photochemical workflow. The digitization process, involving the transition from one medium to another one, when not skillfully controlled is highly prone to the risk of altering, to different degrees, the image originally created on film, as well as altering the effect that the film has on audiences.

Issues in color reproduction

This risk is particularly high when dealing with the reproduction of the original colors of a film. Accurate color reproduction is highly critical not only in films where photography and color design where key defining creative aspects, but also in films whose aesthetic depends just on the stock or color process used, such as it happens with home movies.

The fascinating challenge of accurate color reproduction has been embraced by laboratory technicians and film archivists relatively recently, starting from the 1990s (Ruedel, Currò, Op den Kamp, 2012). Preserving the original colors of silent film prints, where one or more colors have been applied on black and white stock, or of films created using legacy color technologies such as Kodachrome, Technicolor (Kalmus, 1938), Gasparcolor, Ferraniacolor, and Agfacolor has always been tricky, both in the analog and in the digital domain.

Furthermore, despite the unparalleled opportunities offered by digital color correction, digitization reveals issues in color reproduction that have just started to be considered and studied (Diecke et al.,

2020), and that often cannot be dealt with successfully using the commercial equipment currently available.

Nowadays, the main factors that contribute to a flawed reproduction of color in film digitization and restoration can be ascribed to an increasing loss of knowledge in relation to the original film artifact to be preserved and to the way it was originally produced and post-produced. This loss of knowledge is expressed mainly through 1) the loss of knowledge pertaining legacy film color processes and technologies, and how these convey a specific color look; 2) the progressive loss of technical expertise in analog laboratory practices; and 3) the disposal and scraping of laboratory equipment considered obsolete.

Cases

There are many and very different issues related to accurate representation of legacy color technologies in the digital realm. In the authors' opinion some of the most common problems encountered in restoration and digitization workflows can be solved through a better knowledge and understanding of color processes, which can only be achieved through accurate study of the sources (see also Pierotti, 2016).

Sources include the film artifacts themselves, which are the surviving testimony of such processes, and the documentation and literature available on the specific color technology at hand. An important project such as the *Timeline of Historical Film Colors*, developed by Barbara Flückiger, has made a fundamental contribution in this direction¹. However, a full understanding of color films can only be developed after a long hands-on frequentation with them. It is then crucial that archivists and technicians, before performing preservation and color correction duties, are trained in film inspection and get to gain extensive experience by looking at films on the inspection table and – when possible – in the screening room.

With regards to a better understanding of the technologies that originally created film colors, company archives, as repositories of scientific and industrial documentation, are also very important sources. Film heritage institutions should more consistently work together with them when these are still part of an active institution or try to acquire them when they are at risk of being dismissed or dispersed.

Finally, we argue that creative integration of analog and digital workflows, as well as of obsolete and up to date laboratory equipment, should not be overlooked when searching for solutions to specific preservation issues.

Long-time obsolete original techniques for applying color on film are tinting, toning, and hand-painting on black and white stock. These techniques were used extensively in the first decades of cinema history, and nowadays are relatively simple to reproduce, so that they are still used occasionally, often quite successfully and with distinctive results, on a very small scale. The film to be preserved, often the only surviving print of a silent film, can either go through classic photochemical duplication or through the digital intermediate process, which includes scanning, digital restoration and film-out on negative stock. The prints created from the newly created negatives are then chemically tinted and/or toned.

What is commonly considered obsolete lab equipment can come handy when a reliable color reference for an early chromogenic film is not available. For instance, if we have only a negative

¹ <https://filmcolors.org/>

element for an Agfacolor or Ferraniacolor film and no print to serve as a color reference, a possible solution is to create a new print from that negative using a subtractive film printer, which better reproduces the look of the early Agfa and Ferrania film stocks, which had no yellow masking (Hanson, Brewer, 1955). The colors obtained through subtractive printing, can then be matched in the digitized copy through digital color correction. It needs to be noted that today the presence and use of subtractive printers, which starting from the 1950s were progressively replaced by additive printers, is relatively rare in labs, and subtractive printing is a highly specialized service.

It is also worth mentioning possible applications of technologies now considered obsolete in film scanning. For instance, the functioning and calibration of Rank Cintel telecines' flying spot scanner technology is closer to the way we see colors than the one offered by state-of-the-art high-resolution film scanners. Of course, telecines supply only SD scanning, with few HD exceptions.

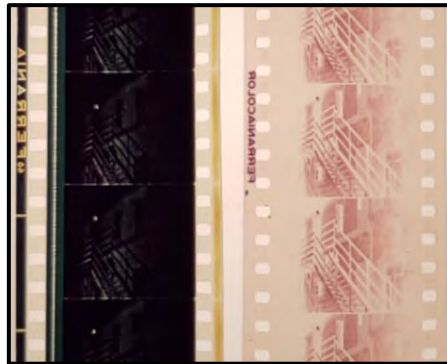
Finally, color considerations can also extend to sound preservation (Lovichi, 1944). We normally assume that color in film concerns only the image track and not the soundtrack. To the contrary, color has fundamental impact on sound extraction from optical soundtracks (Hull, 2004). With the introduction of cyan-dye optical tracks in the early 2000s, sound scanners replaced white light reading heads, suitable for reading silver tracks, with red LED light reading heads. Colored red light will give a distorted sound if used on films with silver soundtracks, which instead need obsolete white light reading heads. Unfortunately, nowadays not all labs are equipped for properly reading optical film sound (Pagni Fontebuoni, 2012).



Chemical tinting and toning in a silent film
(courtesy of Movie and Sound laboratory, Florence)



An ARRI subtractive film printer
(courtesy of Movie and Sound laboratory, Florence)



Ferraniacolor no mask negative printed on Ferraniacolor positive
(courtesy of Movie and Sound laboratory, Florence)

Conclusions

Accurate representation of color in film is often hindered by loss of knowledge pertaining legacy color technologies, and production and post-production workflows connected to these technologies (Pagni Fontebuoni, 2012). Archivists and technicians working at color digitization and restoration need to have a deep empirical and theoretical knowledge of color processes and color stocks.

Also, preservation strategies and solutions should always be developed keeping in mind the basics of the specific color technology that needs to be preserved. Creative solutions developed on a case-by-case basis can help in achieving such goal. These solutions often consist in creative integration of analog and digital workflows, and of state of the art and obsolete technical equipment.

Ultimately, accurate preservation of our film heritage's rich colors is made possible when knowledge of historical color technologies, technical expertise, and versatile and well-maintained lab equipment are also preserved.

Bibliography

- Diecke J. *et al.* (2020) "Lea aus dem Süden. Ethical and practical considerations for digital color transfer", Posted at the Zurich Open Repository and Archive, University of Zurich ZORA URL: <https://doi.org/10.5167/uzh-192008>. Journal article published version originally in: Josephine Diecke, Giorgio Trumpy, Martin Weiss, Barbara Flückiger, "Lea aus dem Süden. Ethical and practical considerations for digital color transfer", in *Journal of Film Preservation*, 103, pp. 95-101
- Hanson W. T. and Brewer W. L. (1955) "Subtractive Color Photography: Spectral Sensivities and Masks", in *Journal of the Optical Society of America*, 45, 6, pp. 476-478
- Hull J. (2004) "Committed to Cyan, Analog Dye Soundtracks Find Wider Acceptance", in *Dolby Laboratories Film Journal International*, September 2004, pp. 38-39
- Kalmus N. M. (1935) "Color Consciousness", in *Journal of the Society of Motion Picture Engineers*, 25, 2, pp. 139-147
- Lovich A. (1944), *Sensitométrie des films sonores*, Laboratoires de Recherches Kodak-Pathé Vincennes – Kodak-Pathé S.A.F

Pagni Fontebuoni M. (2012) “Il restauro delle pellicole cinematografiche”, in Barbara Cattaneo, ed., *Il restauro della fotografia – materiali fotografici e cinematografici, analogici e digitali*, Firenze: Nardini

Pagni Fontebuoni M. (2015) “Il restauro delle pellicole cinematografiche”, in Kermes, 100, October/December 2015.

Pierotti F. (2016), *Un'archeologia del colore nel cinema italiano. Dal Technicolor ad Antonioni*, Edizioni ETS

Ruedel U. *et al.* (2012) “Towards a More Accurate Preservation of Color: Heritage, Research and the Film Restoration Laboratory”, in Brown, Street, Watkins, eds., *AFI Reader. Colour and the Moving Image*, London: Routledge

“Ceci n’est pas un Polaroid”. The Materials and Colours of Paolo Gioli’s works

Sandra Maria Petrillo

SMP International Photo Conservation Studio

Contact: Sandra Maria Petrillo, sm.petrillo@smp-photoconservation.com

Abstract

In the mid-seventies the Italian artist Paolo Gioli (b. 1942) started to use the Polaroid process, not as a means to produce an instant image, but to explore it for his own creative purposes. This paper shares the author’s in-depth knowledge of Gioli’s techniques, in addition to examining conservation issues regarding the particularly fragile materials and colours of his works.

Keywords: Paolo Gioli, Polaroid, contemporary photography, preservation and conservation of color photography

Introduction

In recent years the [SMP International Photo Conservation Studio](#) has been taking care of the Paolo Gioli Archive, (Fig.1) which has allowed us to understand several aspects of the artist’s techniques and given us an in-depth knowledge of the conservation issues regarding the particularly fragile materials and colours in his works. Gioli’s images are not just instant photographs, because they are not produced by the original process, marketed by Polaroid. Instead the artist completely reinterprets it, with his own particular manual interventions and gestures. For this reason I have given this paper the title: “Ceci n’est pas un Polaroid” - *This is not a Polaroid* - in reference to Magritte’s famous painting “Ceci n’est pas un pipe”, in which the surrealist painter ironically explored the relationship between reality, representation and meaning. Paolo Gioli brought much the same kind of disruptive energy to the art of photography which he came to after studying painting and experimental cinema. (Fig. 2).



Fig. 1 - Paolo Gioli
Photo courtesy of Giovanni
Cappello (2016).



Fig. 2 - From the serie “Dürer identikit”, 1982. Polacolor Type 58 and
Polacolor image transfer on drawing paper. Photo by the SMP Studio -
courtesy of Paolo Vampa.

The restoration of contemporary artwork

Interventions of restoration require a comprehensive understanding of the materials used in the creation of the work of art and their processes of alteration, and it would be a mistake to attempt to restore what we do not fully comprehend, either materially or historically. In the context of contemporary art, it is a great advantage to communicate with living artists who are willing to provide vital information on the techniques of execution and materials used. An extremely interesting and valuable dialogue can be established between the artist and the restorer, and it is particularly useful to learn about the material details involved in the creation of their artworks, as this allows us to protect them and preserve them from deterioration. Instead a restorer is generally asked to intervene only when a work has already been damaged. Personally, what has always fascinated me in my work as a restorer is the direct contact we have with the works. We look at them very closely, we touch them and we take care of them, and what could be more valuable than finding out directly from the original source the most precise and detailed facts about how they were created?

Paolo Gioli (born: Sarzano di Rovigo, 1942)

After attending the Academy of Fine Arts in Venice in the early '60s, Gioli moved to New York where he discovered the New American Cinema, and the expressive possibilities that it opened up for the moving image. Following his return to Italy, he started investigating the science of optics and the psychology of visual perception. He combined painting with two other areas of research: experimental cinema, working with 16 mm film, and photography, which he explored by experimenting with non-traditional techniques such as pinhole and slit-scan cameras (Dubois, Somaini, Camporesi and Grignard, 2020).

One of his large paintings entitled “*Superficie vasta della sorgente*” effectively transfers his new interests in film and photography onto canvas (Fig. 3). Consisting of multiple parts in different techniques, the work represents a beam of light rays emitted by an invisible projector that fall at an angle onto a rectangular screen. Due to his interest in cinematographic practices, Gioli soon abandoned the traditional approach to painting altogether seeing it as an art form that freezes an immobile image or confines it within an absolute structure.



Fig. 3 - Paolo Gioli, “*Superficie vasta della sorgente*”, 1970. Consisting of three sections in two different techniques: oil on canvas, charcoal and pastel on paper. Rome, National Gallery of Modern and Contemporary Art. Photo courtesy of Paolo Vampa

Gioli's re-invention of the Polaroid

In Milan, in the mid-seventies, Gioli started to use the Polaroid not so much as an industrial photographic process with a commercial use, but as an extremely versatile expressive means for exploring materials and colours, taking it far beyond the concept of the “instant photo”, invented by Edwin Land. He deconstructed and reinvented the various Polaroid formats and processes for his own creative purposes, using all the constitutive elements of their multiple physical and chemical layers of materials and dyes. Gioli also made some large-format cameras for using the 20x24" Polacolor film (Fig. 4-5), sometimes using this kind of camera without a lens, and taking pictures through a pinhole.



Fig. 4 - Paolo Gioli's 20x24" camera.
Photo courtesy of Giacomo Daniele
Fragapane.



Fig. 5 - Paolo Gioli's studio in Lendinara di Rovigo, Veneto Region. Photo
courtesy of Giacomo Daniele Fragapane.

Gioli's tribute to the old masters and the pioneers of photography

Gioli makes continuous references to the history of art in his work, and many of his photographs are conceived as “tributes” to famous painters, such as Piero della Francesca, Courbet or Dürer. He has also made several films about Muybridge, Escher, Duchamp and Buñuel, but he has focused his attention particularly on the pioneers of photography, creating several major photographs series dedicated to them. These inventors of photography include Joseph Nicéphore Niépce, who made the historic leap from engraving to photography, and the largely unknown Hyppolite Bayard. A highly eclectic and intelligent artist, Gioli critically re-examines and practically re-experiences the creations of those who left their mark on the history of photography, making their work his own and thereby becoming a part of history himself, thanks to the evolution of his own aesthetic approach.

The tributes to Niépce, which he calls “The Niépce of Land”, are a re-elaboration of Niépce's first experiments in producing a photosensitive layer on an engraving plate. As part of his own ongoing exploration of photographic processes, Gioli has made several versions of one of these plates in particular: the “Portrait of Cardinal d'Amboise” (Fig. 6).



Fig. 6 - From the series "Omaggio a Niépce", 1983. Four Polaroid SX-70 applied to drawing paper. Photo courtesy of Paolo Vampa.

In the two works: "Omaggio a Bayard" (Tribute to Bayard) and "L'annegato" (The Drowned Man) Gioli experiments with transfers of Polacolor images onto paper. The "Omaggio a Bayard" is a particularly special work because Gioli took it using the original oversize 20x24" Polaroid camera, which was made available to a few famous photographers in Milan, in 1981, for just a few days. As usual, Gioli did not use this camera and the 20x24" Polacolor materials in a normal or traditional way. He took the photograph – a self-portrait – and instead of developing it through the rolls in contact with the standard photographic paper, he used drawing paper.

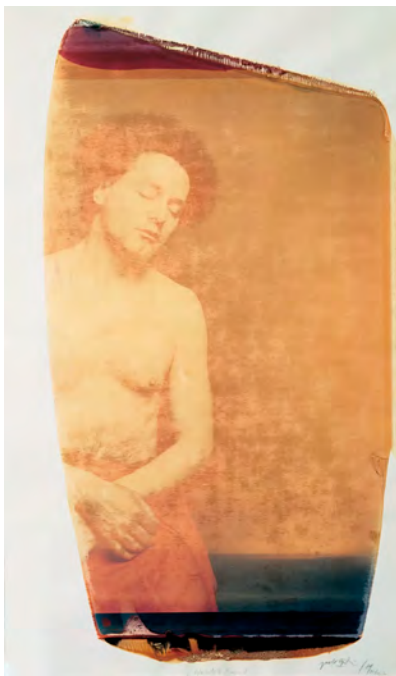


Fig. 7-"Omaggio a Bayard", 1981. Polacolor 20x24" image transfer to drawing paper. Photo courtesy of Paolo Vampa



Fig. 8 - "L'annegato", pinhole photograph, 1981. Polacolor 8x10" - Type 808. Image transfer to drawing paper. Photo courtesy of Paolo Vampa

The irregular shape of the image layer (Fig. 7) is due to the fact that the rolls were moving too fast to evenly spread the chemical reagents across the “receiving paper”.

Another self-portrait entitled “L’annegato” (Fig. 8) is a pinhole image, made using the 8x10” Polacolor sheet film (Type 808). It is the result of an image transfer onto paper, using the emulsion as a printing matrix. Gioli also reworked the developing chemicals with a brush. Both of these works represent the artist's reflections on the correspondences between the direct photographic process invented by Bayard and the contemporary Polaroid instant photography system.

Julia Margaret Cameron, whom Gioli calls “Cameron Obscura”, provided him with a selection of pale and enigmatic young female faces, to which he dedicated an extensive series from 1981 to 1982. These compound images, which he names “compositions”, are the result of an extraordinary kind of modern alchemy. Gioli intervened in the darkroom on the photosensitive layers of the images, which were produced either by contact or by projection. The “Cameron Obscura” series of portraits was made using black and white photocopies, taken from books, exposed in contact with the peel-apart Type 59 material. The colour positives were obtained with the use of coloured lights shone through stencils. In order to create an effect of depth he sometimes inserted a piece of silk screen fabric into the Polaroid sandwich. The image that was formed upon this was then added to his compositions, next to the photographic positive (Fig. 9).



Fig. 9 - "From the series "Cameron Obscura", 1982. Composition with Polacolor Type 59 and image transfers on silk screen fabric, applied to drawing paper. Photo by the SMP Studio - courtesy of Paolo Vampa.

Light is a particularly important element in the artist's work and it is often playfully applied by shining it through cardboard templates, which trace luminous geometric marks in all the colours of the visible spectrum. Gioli often expands the picture space of his compositions with the addition of miniscule strokes of graphite and coloured pencils. Painting, photography and cinema all converge in his work, and he deconstructs and re-constitutes a range of artistic approaches and techniques in a fascinating way.

“Il volto inciso” a series dedicated to Etruscan Art

Thanks to an initiative by the *Fondazione Luigi Rovati* a new museum in Milan is due to open by the end of 2021: the [Museum of Etruscan Art](#). In 1984 Gioli made a series of 44 works dedicated to the Etruscans (Valtorta, 2018) with the title of “Il volto inciso” (The Engraved Face), which were then acquired by the museum. These images were created on the basis of black and white slides of sculpted faces on the Etruscan tombs and funerary monuments conserved in the Guarnacci Etruscan Museum in Volterra (Gioli, Valtorta and Lawrence, 2018). By using an enlarger to project them onto various Polaroid supports, Gioli obtained direct colour positives (Fig. 10).



Fig. 10 - From the series “Il volto inciso”, 1984. Composition with SX -70 and Polacolor Type 58 applied to drawing paper. Photo by the SMP Studio - courtesy of the Fondazione Luigi Rovati



Fig. 11 - From the series “Il volto inciso”, 1984. Composition with image transfer to drawing paper. Milan, Museum of Etruscan Art. Photo by the SMP Studio - courtesy of the Fondazione Luigi Rovati.

The artist intervened on every element of the Polaroid process, disassembling the films, paper supports, protective layers, frames and templates made of black paper and metallized plastic, as well as the chemical reagents themselves, and manipulating them with his own personal artistic gestures. For example, the images transferred to paper show the traces of the Polaroid chemical reagents, spread and smeared upon the paper support, with a spatula or sometimes a brush, in order to obtain a fascinating effect that the artist describes as a “contamination” between traditional painting techniques and the materials of the Polaroid system. In some cases, Gioli also prepared the support with a layer of acrylic paint (Fig.11).

All these works have been exhibited together only once, in 1984, at the *Palazzo dei Priori* in Volterra, and they were then kept in the artist’s private archive until they were bought by the *Fondazione Luigi Rovati*. Their state of conservation is generally quite good, considering the "non-traditional" process of their creation and the colours are particularly well preserved. In fact, in 1975 the colour fading, that Polaroid materials were prone to, was greatly reduced by the introduction of metalized dyes, and in 1976, by the addition of materials in the top layer that blocked the effects of UV radiation (Pénichon, 2013).

The artist used rectangular double-sided adhesive labels to hold the different elements of the compositions together, and to attach the prints to the centre of a sheet of Fabriano drawing paper, which acts as a support and mounting. Over time, however, the layer of glue on these labels lost its adhesive properties and several prints became detached from their mountings, especially at the corners. Seven of the prints had also acquired a lattice of cracks, with raised flakes, clearly visible under a binocular microscope. After examining all of the works with this problem, we concluded that the formation of cracks was the result of a chemical-physical degradation, probably due to the dehydration of the thin layer of gelatine (containing the dyes and chemical reagents) that constitutes the image layer on the developed negative film (Fig. 13).

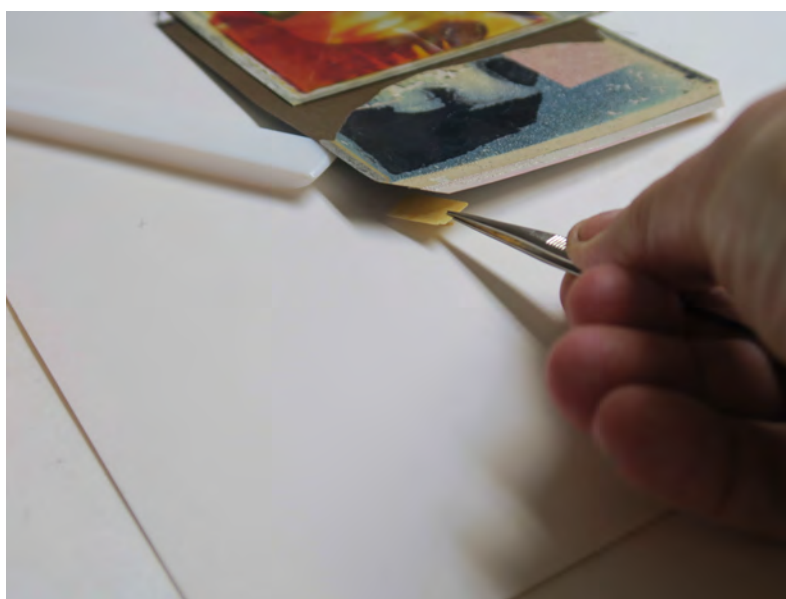


Fig. 12 - 13 - From the series "Il volto inciso", 1984. Milan, Museum of Etruscan Art, Milan. Over time, the layer of glue on these labels has lost its adhesive properties and several prints have become detached from their mountings, especially at the corners. The image layer of this composition shows important cracking and raised flakes. Milan, Museum of Etruscan Art. *Photos by the SMP Studio - courtesy of the Fondazione Luigi Rovati.*

In those cases in which Gioli's compositions had problems of adhesion to their supports, it was first of all necessary to remove the adhesive labels, by inserting a very thin metal spatula between them and the support so that they could be extracted with tweezers. (Fig. 14). New labels were made of 17 g/m² *Kizuki-Kozo* Japanese tissue, of the same size and shape as the originals. In order to make it adhesive on both sides, a film of *Gudy 870®* transferable acrylic adhesive was applied. The print was then slightly lifted with tweezers and a metal spatula and the new label was inserted, thanks to which the print could be firmly attached to the support (Fig. 13).

The seven works by Gioli that had suffered cracking and flaking of the image layer, with the loss of material, were consolidated by means of an acrylic resin - *Paraloid® B -72* dissolved in 5% acetone. The adhesive was applied while viewing the work under the binocular microscope, in order to deposit small amounts of adhesive with the thin tip of a brush. For retouching the tiny losses, we used the highly stable synthetic pigments made by *Gamblin® Conservation Colors* diluted with *Laropal® A-81* (Bailão and Cardeira, 2017).

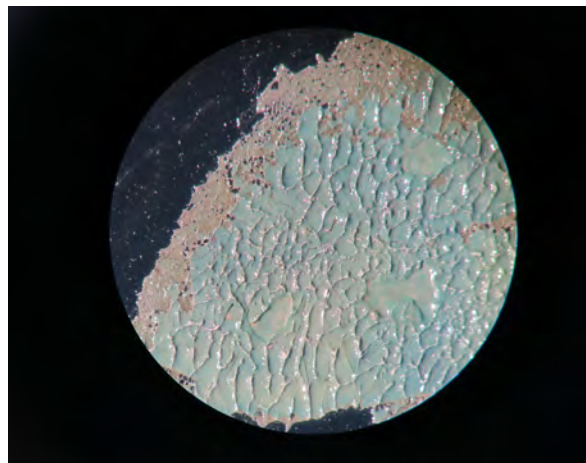
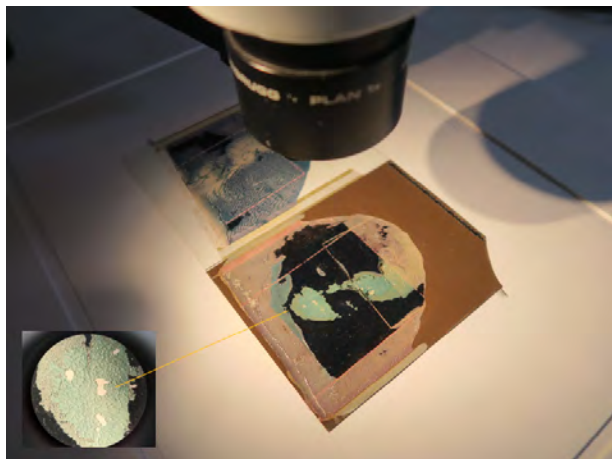


Fig. 14-15 - From the series "Il volto inciso", 1984. The cracked and damaged image layer before and after consolidation and inpainting of losses with *Gamblin® Conservation Colors*. Milan, Museum of Etruscan Art. Photo by the SMP Studio - courtesy of the Fondazione Luigi Rovati.

Each of Gioli's 44 works were attached to an unbuffered conservation board with a thickness of 0.5 mm by means of a series of hinges made of *Kizuki-Kozo* Japanese tissue, of 17 gr/m², glued to the back of the work with *Klucel G®* adhesive (hydroxypropyl cellulose) dissolved in 8% ethyl alcohol. The works assembled in this way were then inserted into thick cardboard mats, and the surface of the image was protected with a sheet of 30 gr/m² non-woven fabric. Finally, all the works were placed in custom-made conservation boxes. Since they were particularly fragile, the seven works in which the image layer had been consolidated were archived separately.

Conclusion

Conservation strategies for the care of contemporary artworks benefit immensely from an ongoing dialogue with the living artist and the collector. Thanks to the information acquired from such direct sources, these works can be preserved more effectively. In the near future we intend to compile and publish more information on the techniques and the Polaroid materials used by Gioli so as to create a significant body of knowledge that can be freely used by the community of conservators, researchers and scholars. In this way the conservation and restoration of these artworks, and others like them, can be ensured, extending their existence, so that they will continue to be enjoyed for many more years to come.

Bibliography

Bailão, Ana & Cardeira, Liliana. (2017). "Mixing and Matching. A Survey of Retouching Materials" pp.248-256, *Postprints RECH 4 Croatia*. [online] Issuu. Available at: <https://issuu.com/rechgroup/docs/postprints_rech_4> [Accessed 13 June 2021].

Gamblin Conservation Colors. 2021. *Technical Data Sheet - Gamblin Conservation Colors*. [online] Available at: <<https://conservationcolors.com/technical-data-sheet/>> [Accessed 13 June 2021].

Dubois, P., Somaini, A., Camporesi, E. and Grignard, É., (2020) *Paolo Gioli. Impressions sauvages*. 1st ed. Dijon: les presses du réel.

Colour Photography and Film:

Sharing knowledge of analysis, preservation, conservation, migration of analogue and digital materials

Gioli, P., Valtorta, R. and Lawrence, D., (2018) *Etruschi Polaroid 1984*. 1st ed. Milan: Humboldt Books, pp. 5-30.

Pénichon, S., (2013) *Twentieth century colour photographs. The complete guide to process, identification & preservation*. 1st ed. London: Thames & Hudson, pp. 232-251.

Valtorta, R., (2018) *Paolo Gioli. Transfer di volti dell'arte*. 1st ed. Milan: postmedia books, pp. 63-77.

A novel compact probe for gloss measurements on photographic films

Giovanni Bianchini¹, Lorenzo Lisi², Barbara Cattaneo³, Marcello Picollo⁴

¹Istituto Nazionale di Ottica CNR-INO

²Università degli Studi di Firenze (UniFi)

³Opificio delle Pietre Dure

⁴Istituti di Fisica Applicata “Nello Carrara” CNR-IFAC

Contact: Giovanni Bianchini, giovanni.bianchini@ino.cnr.it

Abstract

A compact probe based on fiber optics has been developed in order to allow gloss measurements on small samples with a non-homogeneous surface such as photographic negatives. This result has been achieved through a small measurement area, less than 2 mm in diameter, together with the capability of observing a larger area of the sample in order to precisely place the measurement beam. The probe is connected to the light source and the detector system through standard optical fiber patch cables, allowing for a wide range of configurations.

Keywords: gloss measurement, negative films, gelatin coatings.

Introduction

The measurement of surface gloss is widely recognized as an useful tool in cultural heritage conservation, but when applied to photographic film it incurs in significant size limitations. Current instrumentation usually performs measurement on areas of the order of 1 cm² or more (see Fig. 1, right panel), which can be a significant part of the film frame, and can include significant inhomogeneities. Moreover, usually this instruments do not allow a fine control on which part of the sample is actually under measurement, adding further inaccuracy to the result.

To overcome these problems a fiber optics based gloss meter probe has been developed (see Fig. 1, left panel). The probe features an open frame which allows a precise placement of the measurement spot, the spot itself is produced by a collimated beam and has a diameter of than 2 mm at the interaction point.

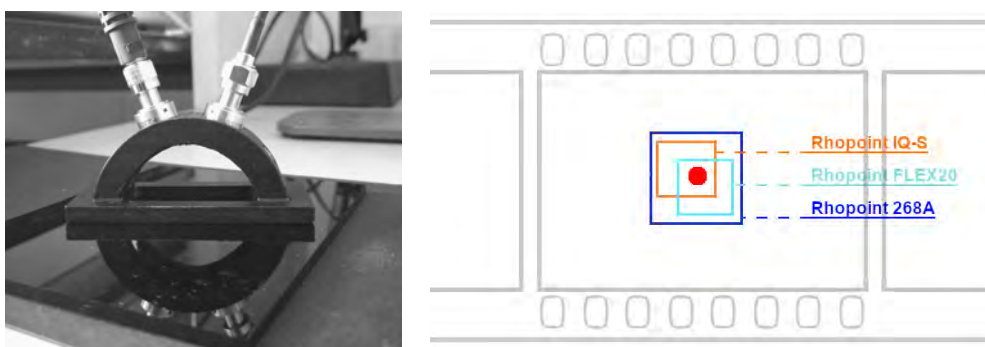


Fig. 1 – A photo of the gloss meter probe with the input and output optical fibers connected (left), on the right panel is shown the comparison between the sampled areas of tour probe (red circle) and some off-the-shelf glossmeters; the area of a 35 mm format photograph is also shown as a reference.

The use of standard optical fibers allows to easily swap both sources and detection systems, in particular the probe can be used with a simple filtered detector to obtain a standard measurement according to the definition of gloss, or with a spectrally resolved detector to increase the information content of the measurement.

The probe allows for the measurement of gloss at a fixed angle, and can be configured to use both the 20°/20° and the 60°/60° geometries (ISO 2813, 2014), which are the standard choice for medium-high gloss materials like photographic film.

Measurements

In Fig. 2, left panel are shown some preliminary measurements performed with the gloss probe, using a Xenon halogen light source and a Zeiss MCS501 spectrometer as detector. The case study considered is the evaluation of the effects on gloss of the application of multiple layers of gelatin in the restoration process of a damaged negative. The measurement show clearly and in a quantitative way the increase of gloss, providing an useful aid to accurately adjust the amount of treatment.

The spectral data show also a second characteristic: while gloss measurements are commonly used to characterize photographic papers (Vessot *et al.*, 2015), the same measurements on films pose some further difficulties intrinsic to the medium, which arises from the fact that light is subject to reflection both from the front and the back surface of the film. In Fig. 2, right panel are shown measurements performed on a sample of non degraded photographic film, both in fully exposed and unexposed conditions. It can be seen that, besides the expected difference in gloss between substrate and emulsion sides, a spectral feature appears above 600 nm, where the gloss measurement of exposed and unexposed samples differ significantly. This can be explained with the contribution of the reflection from the back side, which contributes more in the region where the film substrate is most transparent, and disappear where the emulsion layer is opaque due to exposure.

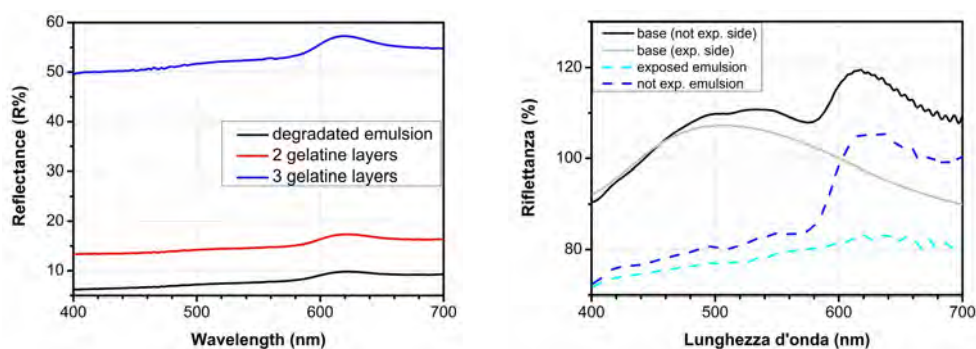


Fig. 2 - Some results of gloss measurements performed on photographic film using our compact probe. On the left a characterization of the effect of multiple layers of gelatine applied to a degraded photographic negative. On the right measurements performed on a non-degraded negative sample, both in exposed and non-exposed condition.

Conclusion

The measurement of gloss on photographic film poses some new challenges due to sample size and morphology, the proposed gloss meter probe allows to overcome the main problems through the use of a small sampling footprint, in order to select areas homogeneous in terms of conservation status and image content. The capability of performing spectral measurements is a further added value allowing the identification and separation of the effects of multiple reflection which are a peculiar characteristic of the film medium.

Bibliography

ISO 2813: Paints and varnishes – Determination of gloss values at 20°, 60° and 85°, 2014-10-01. International Organization for Standardization, Geneva, Switzerland.

Vessot, K. *et al.* (2015) 'Correlation Between Gloss Reflectance and Surface Texture in Photographic Paper', *Scanning*, 37(03), pp. 204–217. doi: 10.1002/sca.21201.

Multispectral capture of film colors with LEDs

Giorgio Trumpy^{1,2}, Jon Y. Hardeberg², Sony George², Barbara Flueckiger¹

¹ Department of Film Studies – University of Zurich

² Colour and Visual Computing Laboratory – Norwegian University of Science and Technology

Contact: Giorgio Trumpy, giorgio@trumpy.eu

Keywords: Multispectral imaging, photographic film, film digitization, film projection.

Limitations of conventional film scanners

The digital reproduction of a historical movie should resemble as much as possible the analog film projection at the time of the movie release. In reality, the professional film scanners that are widely used nowadays in the digitization of archival films were primarily conceived to excel in the *Digital Intermediate* workflow of contemporary film productions (Flueckiger et al., 2018). Their optical configuration is thus optimized for film negative stock of recent production and is not compatible with the vast variety of film processes that constitute the holdings of public archives and private film collections.

The technical limitation of the digital image capture carried out by conventional film scanners is twofold: on the one hand, the limitation is associated with the diffuse illumination of the film, and on the other hand, with the spectral sensitivities of the RGB capture.

A serious limitation of all conventional film scanners is their illumination method that does not properly reflect the conditions of film projection. To guarantee a sufficient brightness on the screen of cinema theaters, film projectors employ parabolic mirrors or condensers that direct the light into the lens that creates the image of the photographic emulsion on the screen (*condensed* illumination). All most popular film scanners capture photographic images illuminating the film with an opal glass or an integrating sphere to achieve a *diffuse* illumination. This type of ‘soft’ illumination has the important advantage of attenuating the dark marks of dust and scratches on the film (Mead, 2006), but it does not conform with the way film is illuminated during film projection. Tinted and toned films and other early film colors produce quite different appearances in diffuse and condensed illumination: the condensed illumination creates an image with deeper darks and more evident grain, while the diffuse illumination creates an image with lower global and local contrast (Gregory, 1927; Streiffert, 1947). If the diffuse/condensed discrepancy is not properly taken into consideration, early film colors risk to be improperly digitized and their digital version will not match the appearance of the original analog projection (Trumpy and Flueckiger, 2019).

Conventional film scanners can be ascribed to two categories according to the spectral width of their RGB bands. On the one hand, there are spectral bands that do not overlap, aiming at the absorption peaks of typical dyes of modern chromogenic films (cyan, magenta and yellow); these *narrow bands* are conceived to extract information about the concentrations of the film dyes and enhance the resulting digital color (Gschwind, Frey and Rosenthaler, 1995). On the other hand, there are spectral bands that largely overlap; these *broad bands* are conceived to resemble the human visual system and aim at color rendition in accordance with human perception. These fixed categories represent a strong limitation for the digitization of film colors, as some types of film should be digitized aiming at the maximum digital color information, while the color accuracy is most important for other types (Trumpy and Flueckiger, 2015). For example, it is preferable to digitize a faded chromogenic film with narrow bands, as this offers a more effective digital restoration. However, the enhanced colors produced by the narrow bands become excessive whenever a well-preserved projection print has to be reproduced (Fossati, 2009).

A new multispectral imaging system

To overcome the limitations reported in the introduction, a multispectral imaging system was designed and built, serving as a prototype of a new film scanner that can produce the most suitable digital image for all types of historical film. The film (Fig. 1-G) is illuminated with a condensed beam that resembles illumination of film projection. The possibility to insert a light diffusing slab close to the film (Fig. 1-F) allows to switch between condensed and diffuse illumination, thus benefiting from a true-to-projection color rendering, as well as from attenuated marks of dust and scratches. According to the type of film stock and its physical conditions, the scanner operator has the possibility to choose between the two types of illumination. The film scanner also allows to capture each film frame in both diffuse and condensed illumination, thus opening the possibility for image processing procedures that combine the advantages of both illumination conditions.

For each photographic image, the imaging system captures the spectral images sequentially on an area array sensor. The illumination is provided by a set of ten light-emitting diodes, whose emissions determine the spectral bands of the imaging system. In order to let all LEDs homogeneously expose the field-of-view with a condensed beam, it was necessary to efficiently bring their light to a common area where the ray bundle of all the LEDs has a similar geometry. To achieve this condition without moving parts, a custom-made integrating sphere has been 3D printed in resin (Figure 1-A), having a 12 cm diameter and whose interior has been sprayed with a nearly-Lambertian reflectance coating. The LEDs (Fig. 1-C and -B) shine light inside the sphere through the entrance ports, and after being scattered, the light comes out from the 2 cm diameter exit port at the top of the integrating sphere. The light coming out from the sphere is collected by a first condensing lens (Fig. 1-D) with a numerical aperture of 0.76 that allows to minimize the dispersed light. The second condenser (Fig. 1-E) has a diameter of 75 mm and a focal length of 200 mm. The system is configured in such way that the beam is slightly diverging between the two condensing lenses—so to increase the illuminated area—and the image of the sphere's exit port is created approximately where the aperture of the imaging lens is positioned (Fig. 1-I).

The camera (Fig. 1-J) has a back-illuminated full-frame CMOS monochrome sensor with 61 megapixels, and it is equipped with a 100 mm macro lens. The field-of-view necessary to fully cover—perforation area included—the 135 still photography format is 54×36 mm. The resulting resolution is 4500 ppi, which is enough to capture the relevant detail of a fine-grain photographic image on film.

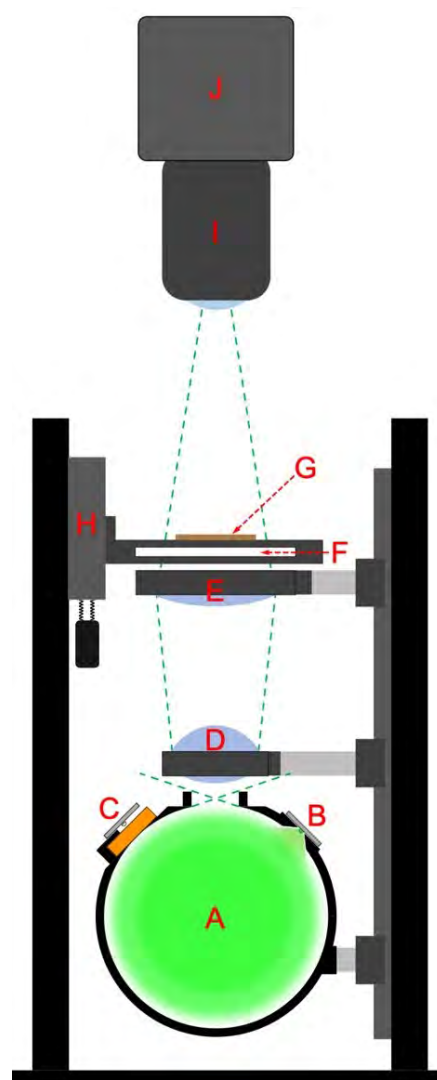


Fig. 1 - Diagram depicting the integrating sphere (A), one of the LEDs that directly shines into the sphere (B) and one of the LEDs that shines through an interference filter (C). The first (D) and the second condensing lens (E). The sample holder with the light diffusing slab (F), the focusing stage (H) and the film sample (G). The imaging lens (I) and the monochrome camera (J).

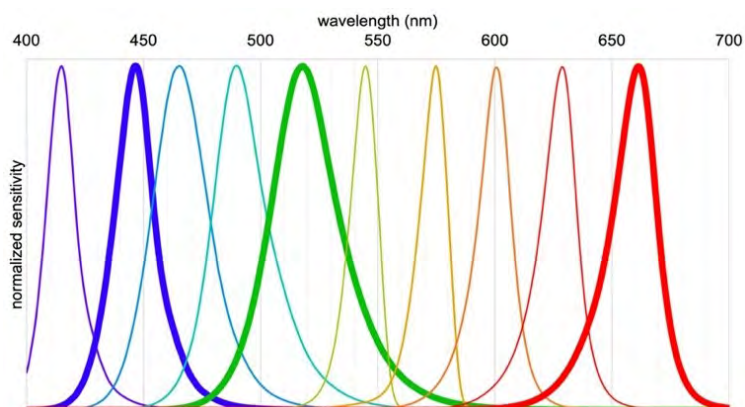


Fig. 2 - The normalized spectral bands of the multispectral imaging system. The thick curves indicate the RGB narrow bands used by conventional film scanners.

In the presented imaging system, the multispectral capture comprises ten spectral bands that are evenly distributed in the visible spectral range and have limited overlap (Fig. 2). Since no LED can be found on the market with a narrow emission peaking between 530 and 590 nm, two broad-band LEDs shine through two different interference filters (as depicted by “C” in the diagram of Fig. 1). Three bands of the final set reported in Fig. 2 (the thicker curves) correspond to the conventional red, green and blue narrow bands described in the previous section. This allows to either enhance the digital color information by selecting the red, green and blue bands only, or to make use of all the spectral bands and obtain the most accurate colors. This flexibility allows to properly digitize all types of film colors: well-preserved projection prints as well as faded dyes, non-standard colors of early cinema as well as camera negatives and other intermediate film elements.

Image capture and processing

A preliminary calibration procedure is necessary before capturing the film every time the system has been reconfigured (i.e., repositioned camera or illumination system). For each LED, after identifying the integration time that makes the best use of the linear dynamic range of the sensor, two images of the empty gate—without film—are captured and stored: the “white” image with the LED on and the “dark” image with the LED off. The film frame is captured with the same integration times, and a *flat-field* operation computes the film’s transmittance values that are expressed with 16 bits and stored as data-cube file (ENVI Header Files [Internet] 2020).

The multispectral system was tested on a set of slides from the holdings of the Art Institute of Chicago. The image content and transmittance values are reported in Fig. 3 for one of the slides. The color image is the result of colorimetric calculations performed on the data-cube file (Schanda, 2007).



Fig. 3 - An edge-to-edge multispectral capture of a slide with the LED-based system (left). Bottom-right: Image detail of the car roof. Top-right: Transmittance values corresponding to the yellow skirt of doll on the left and to the red turban of the doll on the right. Courtesy of the Art Institute of Chicago.

Conclusion

A multispectral method for image capture of film could greatly improve the digital cinematic experience and its fidelity with the supposed visual experience in the cinema theaters of the past. The urge of such innovation has been demonstrated in the framework of the ERC Advanced Grant *FilmColors* at the University of Zurich by analyzing the multitude of historical color film processes, investigating their optical properties, developing and testing a multispectral scanner prototype, and

gathering the feedback of experts during simultaneous analog/digital projections (Op den Kamp, 2020). In the late 2020 the optical design of the future multispectral film scanner and the computational pipeline of the captured images have been further elaborated at the Norwegian Colour and Visual Computing Laboratory. The collaboration resulted in a new imaging system in transmission mode that efficiently captures multispectral images of photographic film and offers inspiration for the future development of a new generation of film scanners.

Acknowledgements

The construction of the multispectral imaging system was funded by the project IMATCH from the Norwegian Regional Research Fund (RFF Innlandet) – grant No 298914. Tor Erik Nicolaisen and Monika Skaug Bakkehaug gave support for the 3D modeling and printing, Luvín Munish Ragoo for the electronics, Binu Melit Devassy and Ronny Xavier Velastegui Sandoval for the software. Jean Baptiste Thomas and Julius Muschaweck gave fundamental advice for the optical design. Special thanks go to Sylvie Pénichon who provided the slides for the experiments. The fundamental concept that inspired the work have been developed under the European Union’s Horizon 2020 research and innovation programme – grant agreement No 670446 *FilmColors*.

Bibliography

ENVI Header Files (2020) *Harris Geospatial Solutions*. Available at:

<https://www.l3harrisgeospatial.com/docs/enviheaderfiles.html> (Accessed: 20 May 2021).

Flueckiger, B. *et al.* (2018) *Investigation of Film Material–Scanner Interaction*, Available at:

<https://diastor.ch/results/#SCAN>.

Fossati, G. (2009) *From Grain to Pixel. The Archival Life of Film in Transition*. Amsterdam: Amsterdam University Press.

Gregory, C. L. (1927) ‘Tinting and Toning Motion Picture Films’, in *Motion Picture Photography*. 2nd ed. New York City: Falk publishing Company, Incorporated, pp. 177–198.

Mead, T. W. (2011) ‘Optical scatter correction for film scanners’, US 8,009,190 B2 (2011).

Op den Kamp, C. (2020) “‘If You Build It, They Will Come’”, *Film Colors. An Interdisciplinary Approach*. Available at: <https://blog.filmcolors.org/2020/03/09/vecoscan/>.

Rudolf Gschwind, Franziska S. Frey, and Lukas Rosenthaler (1995) ‘Electronic imaging: a tool for the reconstruction of faded color photographs and color movies’, in. *Proc. SPIE 2421*.

Schanda, J. (2007) ‘CIE Colorimetry’, in Schanda, J. (ed.) *Colorimetry. Understanding the CIE System*. 1st ed. Vienna, AT: Hoboken, N.J: Wiley-Interscience.

Streiffert, J. G. (1947) ‘Callier Q of Various Motion Picture Emulsions’, *Journal of the Society of Motion Picture Engineers*, 49(6), pp. 506–522.

Trumpy, G. and Flueckiger, B. (2015) ‘Light Source Criteria for Digitizing Color Films’, in *2015 Colour and Visual Computing Symposium (CVCS). IEEE*, pp. 1–5.

Trumpy, G. and Flueckiger, B. (2019) ‘Chromatic Callier Effect and its Repercussions on the Digitization of Early Film Colors’, *Journal of Imaging Science and Technology*, 63(1), pp. 10506-1–11.

Observations on Preservation Issues for Contemporary Photography Artworks

Roberta Piantavigna¹

¹San Francisco Museum of Modern Art

Contact: Roberta Piantavigna, rpiantavigna@sfmoma.org

Extended Abstract

Introduction

This study presents observations on the preservation issues of contemporary photographic works and argues that a new methodology is needed to devise responsible preservation strategies encompassing the complexity and heterogeneous nature of these works.

Contemporary artists experiment with photography and its endless possibilities producing works that can resemble traditional photographs, as we know them, or radically differ from them. Collecting institutions are responsible for reviewing, refining, and adapting their accession, cataloging, documentation, and preservation practices over time as the artworks, approaches, and collection management procedures change. New practices and preservation strategies should be implemented when the museum's existing ones appear inadequate to accommodate the needs of new artworks. This study argues that this is the case of contemporary photography artworks with more similarities with complex art installations than traditional photographs. Three case studies will be presented to highlight how the acquisition of non-traditional photographic works has challenged preservation best practices at the San Francisco Museum of Modern Art.

Photography conservation literature is an important resource for conservators who grapple with preservation concerns of works of the collection. In the context of this study, a survey was conducted of Topics of Photographic Preservation, the main point of reference for photography conservators, to understand what resources are available on the preservation of contemporary photography. Preliminary results are presented and show that the topic has not received much attention from the photography conservation community.

Conservators who recognize the limits and flaws of museums' existing approaches have the responsibility to address the issue and propose a new methodology for preserving non-traditional photographic artworks. Conservation disciplines that have dealt with the preservation issues of contemporary art can provide critical insights to photography conservators who recognize the urgency to develop new approaches and methods for their understanding and care of contemporary photographic artworks.

Preservation Issues for Contemporary Photography Artworks

The San Francisco Museum of Modern Art is one of the first American institutions to collect photographs starting in the 1940s when the media was not fully recognized as an art form. Today, the museum photography collection comprises more than eighteen thousand photographic objects that tell the history of photography, art, and our time. Museum accession, cataloging, and conservation procedures have been developed and refined over time to accommodate the preservation needs of all photographic artworks. Contemporary photography productions do not always fit within the existing material-based categories that museum usually deals with. The increasing number of acquisitions and exhibitions of less traditional works, such as photography installations and digital-born works signal curators' interest in presenting contemporary artistic productions that speak and reflect on the contemporary blurry boundaries between still and moving images, material and immaterial. Creative and timely solutions are devised on a case-by-case basis to store and catalog these complex artworks immediately after they are acquired. Often these solutions lack of a methodology that contemplates the long-term preservation of the work, the artist's voice, and the artwork's conceptual and material nature.

Three recent photography acquisitions at SFMOMA are presented as case-studies.

The work *241543903* (2009-ongoing) by David Horvitz is a meme, an ongoing social-media experiment in which digital images are shared and experienced on the internet via social media. In 2009, the artist invited people on the street and on the internet to take pictures of themselves with their heads in the freezer and to post them on social media (fig.1). In 2019, *241543903* was exhibited in the museum galleries as the artist, and the curator worked together to stage the work's first physical manifestation. Images of people with their heads in the freezer were printed and pinned to the gallery walls. A functioning fridge was placed in the middle of the gallery, and visitors were invited to interact with it and to enact the meme.



Fig. 1 – Installation view of the work *241543903* (2009-ongoing) by David Horvitz displayed at SFMOMA in 2020. Photo credit: SFMOMA

Ponte City (2008) by Mikhael Subotzky and Patrick Waterhouse is a works and entire art installation of found objects and prints, ephemeral material, and large framed inkjet prints. It represents the creative collaboration project between the two artists, who attempted to document the complex history and reality of Ponte City Tower, a brutalist cylindrical high-rise that towers over Johannesburg and tells the stories of the people who lived and still live in it.

The People's View (2014-ongoing) by Rein Jelle Terpstra is a living archive of vernacular photographs, super 8mm films, and original videos created by the artist. Inspired by the work *RFK Funeral train* by Paul Fusco, the artist sought out via social media the people who, on June 8th, 1968, lined up by the railway tracks from New York to Washington to pay their last respects to Senator Robert Kennedy, who was murdered just days before. He collected their photographs and films with the intent to build a living archive of collective memories.

These three acquisitions present original analog and digital photographic material and components made by the artists and collected from third parties. The latter are presented by the artists a integral parts of their works, conferring them new meanings, formats, and relationships: a process that is not uncommon in photography. When these works enter the museum collection, our notions of authorship

and authenticity are challenged and raise questions on what the museum is tasked to preserve and what strategies should be devised for the long-term preservation and future display of these works. What should be preserved of an ongoing internet-born artwork, as Horvitz's? How to describe and be transparent about the authorship of the found materials? Photography conservators, curators, registrars, and collection experts grapple with complicated ethical and practical questions. They are pressed to find timely solutions, which results in privileging the material aspect of the work and leaving unresolved the more conceptual ones. Acknowledging that these works have different needs and require special attention than most photographs is the first step to admit that our understanding, approach, and practice with contemporary photography need to be reviewed.

Survey on Photography Conservation Literature: preliminary results.

To better understand how the preservation issues with contemporary photography artworks are addressed in the conservation community, this study aims to collect data and case studies by reviewing the main field's publications. The results will help understand what resources are available to conservators to develop a methodology for the proper care of contemporary photography artworks. *Topics in Photographic Preservation* gathers most of the contributions made in photography conservation and can be considered the most comprehensive literature reference point for conservators. The Photographic Materials Group (PMG) of the American Institute for Conservation (AIC) is published biennially by the Photographic Materials Group (PMG). It comprises papers presented mainly at the PMG session of the AIC annual meeting and the PMG winter meetings. Its first volume dates 1986, and over time scientists, conservators, historians, and other experts have contributed to it with studies on a vast array of topics around photography and its preservation, forming an invaluable body of knowledge for the discipline of photography conservation.

A dataset was built with all the four-hundred-seventy-two submissions contained in the eighteen volumes of *Topics*. All submissions were reviewed and filtered by two main criteria:

- "Contemporary Topics": submissions which topic is a study of material, photographic technique, or treatment on objects dating after 1970, as this date is commonly used in art history to pinpoint the beginning of contemporary art. Scientific studies on digital and chromogenic materials and their stability have been included in this selection.
- "Contemporary photography conservation issues": submissions with a specific focus on this topic.

Of all the submissions, "contemporary materials or techniques" have been the topic of ninety-five papers, of which only twelve have addressed specifically contemporary photography conservation issues (fig.2).

The topics of these twelve submissions range from case studies on the preservation and installation of contemporary artworks to the issues of reprinting and the importance of a shared terminology in our field. All the submissions that do not match the two criteria address all kinds of topics: material and process technical studies, conservation techniques, scientific analysis of photographic materials, etc.

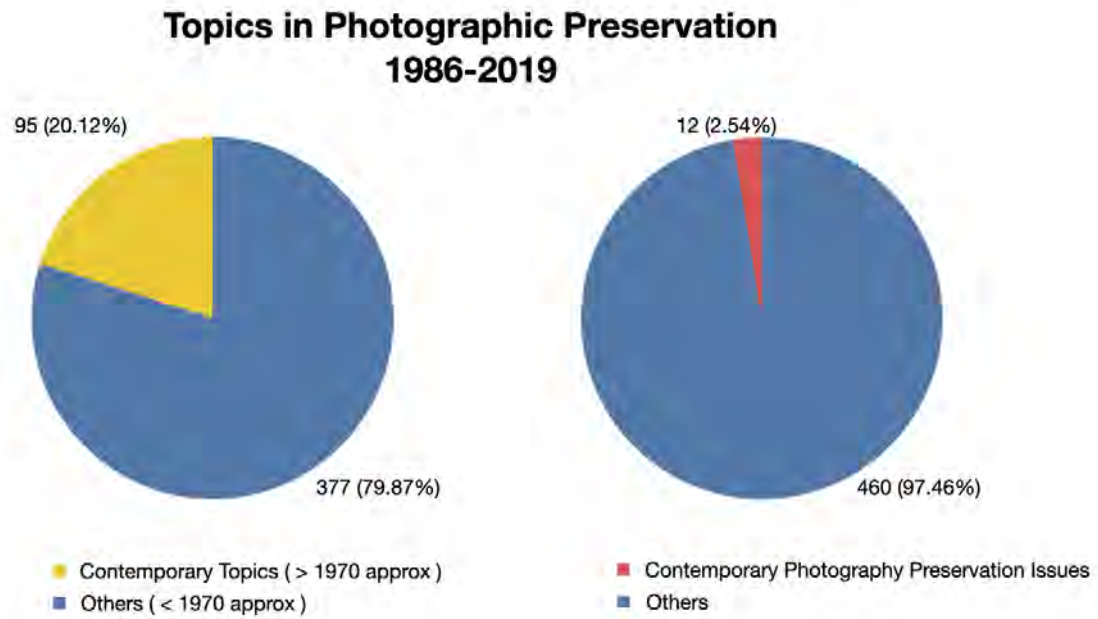


Fig. 2 – Pie charts showing the results of the survey on the 472 submissions of Topics in Photographic Preservation.

In figure 3, representing a bar chart, the timeline helps understanding when these submissions were made. As 2020 approaches, the percentage of submissions on contemporary photography preservation issues increases, showing that conservators are dealing with them in their institutions and studios as they become more pressing; however, this number represent still a relatively small portion of the overall contributions made in the last two decades. Important contributions that were made by conservators on the preservation issues with contemporary photography are not represented in this study, as they were not published in Topics.

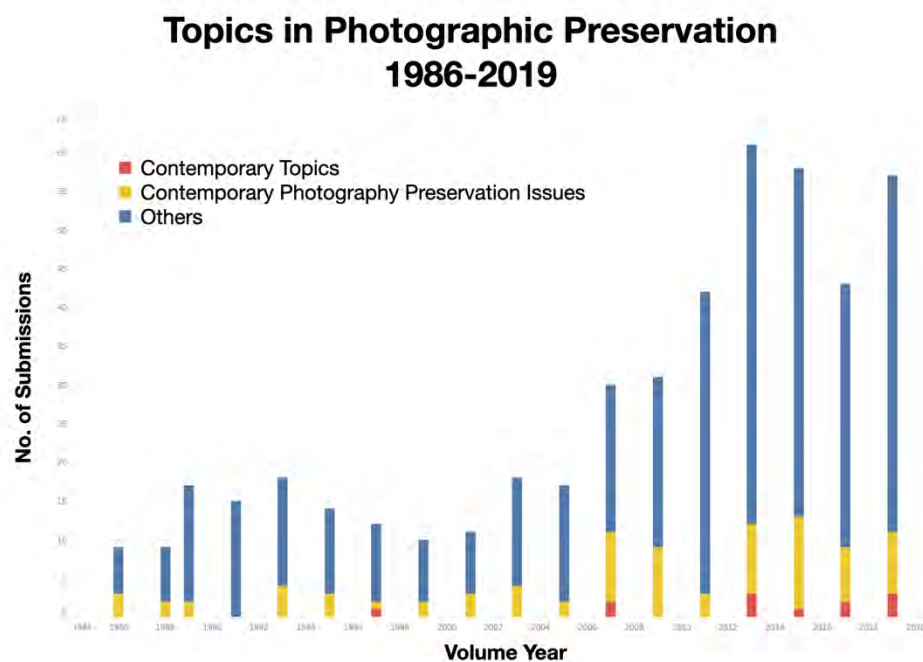


Fig. 3 – Bar chart showing when submissions with topics on “contemporary photography” or “contemporary photography preservation issues” were submitted.

Conclusions

Surveying Topics' submissions from 1986 to 2019 allows us to reflect on the history of photography conservation as a discipline and recognize the fundamental collaboration between conservators and other preservation experts, especially scientists. These preliminary results are a starting point for a more in-depth investigation of the literature resources available to support the development of new methodologies and approaches to preserve contemporary photographic artworks. As conservators may be challenged to perform their work with more limitations in resources and access due to the pandemic and museum financial crisis, a reflection on how our profession can remain relevant in a changing world is paramount. Conservators' knowledge and expertise on photography preservation issues have the potential to expand further. Dealing with the complexity and immaterial aspects of photography is critical for our role in the present and the future of cultural heritage preservation. Researching and learning the theoretical and philosophical frameworks of other conservation disciplines, collaborating with their experts, living artists, and their network of producers are fundamental steps to inform, adapt, and evolve our approaches to photography and preservation.

Preserving the Process Knowledge of Dye Transfer Printing

Tess Hamilton¹, Nora Kennedy²

¹ The Conservation Center of the Institute of Fine Arts, New York University

²The Metropolitan Museum of Art

Contact: Tess Hamilton, tess.b.hamilton@gmail.com; Nora Kennedy, nora.kennedy@metmuseum.org

Extended Abstract

With the rise of digital printing, analog color photographic printmaking is disappearing. As materials become unavailable, and expert printers retire or commit to digital processes, the knowledge of how to activate these complex and nuanced analog color technologies are at risk of being lost. This knowledge is essential to the preventive conservation of these ever more unique photographs, and lends depth to their appreciation.

One rapidly vanishing color process is dye transfer printing. Developed by Kodak in the 1940s, dye transfer was one of the premier color processes of the 20th century, and was valued for its nuance, rich colors, dense blacks, high degree of control, and high dark stability when compared to contemporary color photographic processes. Dye transfer is a type of continuous tone, three-color printing process that relies on subtractive color separation negatives that are used to print hardened gelatin relief matrices. These matrices are then dyed cyan, magenta, and yellow, and laid in succession on a piece of paper with a gelatin layer containing a mordant. The dyes are imbibed into the gelatin layer and complex with the mordant to create the final color print.

Throughout the sixties and seventies, New York City became the main hub of dye transfer printing, with nearly a dozen professional labs and master printmakers working for advertisers and artists. The process reached its pinnacle in these professional labs where printers developed complex and nuanced printing techniques and workflows to create the greatest consistency and control using the Kodak products. Despite being the gold standard of color printing in the second half of the 20th century, with the increasing potential of digital technology, the materials were discontinued in 1994.

While dye transfer printing is all but obsolete, a small number of artists and printers in the industry have remained dedicated to preserving their craft including Guy Stricherz and Irene Malli of CVI LAB. Stricherz and Malli are master dye transfer printers with over 75 years of combined experience in the craft. They have printed thousands of editions for artists including William Eggleston, Mitch Epstein, Zoe Leonard, and Irving Penn. Through a stockpile of materials, CVI LAB continues to make dye transfer prints to this day.

Over the past several years, Guy and Irene partnered with conservators across institutions to create a set of prints for *The Photographic Analog Process in Film and Print Sample Set*. The sample set was an edition of 300 that included a range of analog color processes including dye diffusion, chromogenic prints, and silver dye bleach materials. Thanks to the generosity of many donors, the sets were given, free of cost, to institutions and conservators in 49 different countries to serve as tools for outreach, teaching, research, and photographic identification for both specialists and non-specialists. In February 2020, Guy and Irene donated the process materials used to create the prints to the Metropolitan Museum of Art Photograph Conservation Department's Study Collection. The gift included masks, dyes, filters, negatives, and test prints, and was accompanied by detailed notes, and audio and video recordings to further elucidate the details of the process.

Guy Stricherz and Irene Malli's donation created a valuable resource to allow researchers to understand the dye transfer process from the perspective of the craftspeople that made the prints themselves. As fewer practitioners work with analog color printing, study collections become

essential to archive, not only the prints, but also the practices used to make them. The best way to preserve this information is through networks of expertise, where artists have the platform and resources to share their knowledge, and institutional support to ensure that that knowledge is documented, and those documents are preserved and made accessible in the long term. Conservators and conservation study collections, which intersect with art, material knowledge, and technical knowledge, can become ideal repositories for this essential information. By providing, not only material, but also notes and oral histories about their careers and lab, Guy Stricherz and Irene Malli have begun the difficult and complex process of documenting and preserving intangible craft practices for future generations. This collection will help non-practitioners better understand and preserve the lineages, networks, local developments, and darkroom practices behind dye transfer printing, and more thoroughly appreciate the dye transfer prints found in museums and archives.

The goal of this project is to supplement this invaluable collection with descriptions, illustrations, and animations, creating a comprehensive digital resource that explains and reactivates the dye transfer process. By using a digital platform, the study collection can create a multimodal and network-like approach to learning. A digital education tool explaining the process can improve access to the collection by making it available outside of the museum walls, while also creating a branching approach to learning, where a user can both see an overview of the process or can dive deeply into its intricacies. This project is a collaboration between CVI Laboratory, The Metropolitan Museum of Art's Photograph Conservation Department, and Tess Hamilton, a student at the Conservation Center of the Institute of Fine Arts, New York University. Their collaboration allows for a synthesis of expertise in art history, process knowledge, education, and conservation to expand on and share the study collection with researchers regardless of their background in photographic practice, and to preserve intangible craft knowledge in a holistic and innovative manner that considers materials and artists, and the printmaking expertise required to bring them together.

In a time when virtual learning and digitized research materials are necessary to share knowledge within and beyond local communities, this project provides an exciting opportunity to use digital technology to activate an analog technique for a 21st-century audience and to preserve the art of dye transfer printing for future generations. The knowledge of how dye transfer prints are made and the dye transfer prints and process materials serve to enrich each other, and our understanding of the color process and the history of color photography more broadly. This approach to color technologies and darkroom practice can serve as a model for the preservation of fleeting and rapidly obsolete photographic crafts.

The Lippmann Plate at the Fondazione Scienza e Tecnica in Florence

Anna Giatti

Fondazione Scienza e Tecnica

Anna Giatti, collezioni@fstfirenze.it

Abstract

The Fondazione Scienza e Tecnica, in Florence, Italy includes an interferential Lippmann chromophotograph that entered the collections from the University of Florence. The FST has planned a conservation project for this plate which includes restoration and preventive conservation treatments.

Keywords: Lippmann plate, colour photography, interferential photography, interferential Lippmann chromophotograph, color photograph conservation.

Introduction

One of the most difficult challenges of historical photography was color reproduction. Notable contributions came from the most renowned scientists of the Nineteenth Century who were searching for solutions within the field of photochemistry. However, a key breakthrough was discovered by Gabriel Lippmann (1845-1921) (Fig. 1). In 1891, Lippmann presented to the Académie des Sciences in Paris a method for capturing a color photograph of a solar spectrum. Over the next few years, he also perfected his process for the reproduction of real objects. Lippmann's procedure exploits the physical phenomenon of interference generated by a highly reflective surface placed in contact with the photographic emulsion during its exposure (Fig. 2). Despite the technique's exquisite beauty and the impressive results, the process did not gain widespread adoption due to its complex requirements. However, his discovery stands as a milestone in the history of physics as well as in that of the color theory and in 1908 Lippmann won the Nobel Prize for his achievement.



Fig. 1 - Gabriel Lippmann in the Sorbonne Physics laboratory which he led for 35 years.

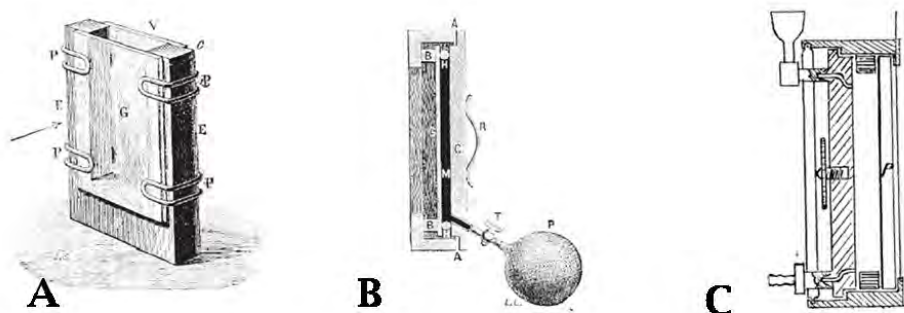


Fig. 2 - The camera plate holders, where a quantity of mercury is allowed to flow in and stay in contact with the photographic plate (emulsion side) forming a highly reflective surface. A is the design proposed by Lippmann; B the one improved by the Lumière brothers; and C the one commercialized by the German manufacturer Zeiss in the 1910s.

The Lippmann plate from the University of Florence to the Fondazione Scienza e Tecnica

In the 1990s, the Fondazione Scienza e Tecnica received an important collection of historical scientific instruments and laboratory supplies from the Department of Physics of the University of Florence, including an interferential Lippmann chromophotograph (Fig. 3).

The Occhialini archive at the University of Florence, holds a correspondence between Augusto Occhialini and Gabriel Lippmann which mentions three colored "clichés". It was 1914 and Lippmann gave these "clichés" to Occhialini to demonstrate them to the Italian Physical Society. We know that the showing never occurred, but we are awaiting confirmation of our belief that there is a link between those "clichés" and the Lippmann chromophotograph in our collection.



Fig. 3 – The Lippmann plate at the Fondazione Scienza e Tecnica, Florence.

The research and the conservation plan

Recently, contacts made with the Musée de l'Elysée in Lausanne, regarding their census on existing Lippmann plates, provided the opportunity to start a process of study and conservation of the aforementioned plate. The research started in December 2020. The conservation and restoration project was developed with Barbara Cattaneo and the Opificio delle Pietre Dure in Florence and includes investigations aimed at identifying the processes and materials involved in both the production of the plate and its state of degradation.

The EU APACHE Project for the preventive conservation of cultural heritage

Fortunately, many of the materials that compose our Lippmann plate are quite well preserved and the aim of our planned analysis and conservation treatment is to ensure its preservation for the future. Due to the plate's packaging, it is challenging to achieve the goal of periodical degradation-state assessments. The packaging also poses a challenge to any restoration treatment of the internal object, so it is important to do our best to avoid any degradation processes. It should be noted that, in order to make the plate properly available to the public, it is displayed in an historical showcase together with other items made of an array of materials that could injure it through VOC emission.

Effective measurements for preventive conservation are essential and we find them in the context of the APACHE EU project, where Fondazione Scienza e Tecnica is partner.

The APACHE's aim is to develop innovative and affordable solutions for the preventive conservation of tangible, movable and indoor cultural heritage. The project will develop a range of materials and tools based on multi-scale modelling and a new generation of active and intelligent storage and display solutions to support the long-term preservation of Cultural Heritage.

The APACHE project - started in January 2019 and spanning a 42-month period - has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No814496. For more details please visit www.apacheproject.eu

Bibliography

Gamble S. (2002) 'An appealing case of spectra: photographs on display at the Royal Society, London 1891', *Nuncius* 17(2), pp. 635–651.

Lippmann, G. (1891) 'La photographie des couleurs', *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences*, 112, pp. 274-275.

Lippmann G. (1894) 'Sur la theorie de la photographie des couleurs simples et composees', *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* 118(92–102), p. 101.

Mitchell D. J. (2010) 'Reflecting nature: chemistry and comprehensibility in Gabriel Lippmann 'Physical' method of photographing colours' *Notes Rec. R. Soc.* 64, pp. 319–337. doi:10.1098/rsnr.2010.007.

'Nobel lectures: physics 1901–1921 (1964)', Elsevier, Amsterdam, pp. 183-190.

Re-makeable Art and the digitally constructed image: Case study of Geoff Kleem's wallpaper installation

Analiese Treacy¹, Asti Sherring²

¹ Senior Conservator – Paper, Art Gallery of New South Wales

² University of Canberra

Contact: Analiese Treacy, analiese.treacy@ag.nsw.gov.au; Asti Sherring, a.sherring@me.com

Keywords: time-based-art, wallpaper, contemporary art, installation art, digital preservation, photographic mural

Extended Abstract

Geoff Kleem is a Sydney born artist who has had a career spanning over three decades. His work has included the mediums of photography, installation, and objects of heterogenous variety – and critics have said of his works, that '*there is always a danger of getting lost in their intriguing detail*' (Clement, 2016). Having exhibited widely in Australia and internationally and having completed residencies in the USA and Japan, Kleem's work is largely motivated by visitor experience. As Kleem explains,

I want the viewer to be able to respond, to find meaning in my work that is their own
(Kleem 2016, p.145).

The site-specific installation, *Untitled 2016 -2017* (Figure 1) commissioned by Art Gallery of New South Wales (AGNSW) in 2015 and purchased with funds provided by a generous benefactor, is a compelling large-scale photographic mural. Printed between 2016 -2017 the work is a compelling large-scale photographic mural 11 meters long and 3.5 meters high – running from ceiling to floor. Due to its scale the work is made up of 9 sheets of wallpaper with a flour based adhesive backing, designed to be installed by a team of print and production specialists. In this work Kleem uses digital software tools, including Adobe Photoshop and takes architectural components from various museum and gallery spaces around the world, reconstructing and relocating them to create a false 1:1 ratio image of an 11-metre-long Gallery wall. The work creates a dramatic intervention within the AGNSW site by representing itself as a believable architectural element of the space. As described by the artist,

the work engages with notions of photography, sculpture and installation as a means of critically exploring our relationship with visual culture (Art Gallery of New South Wales 2015).

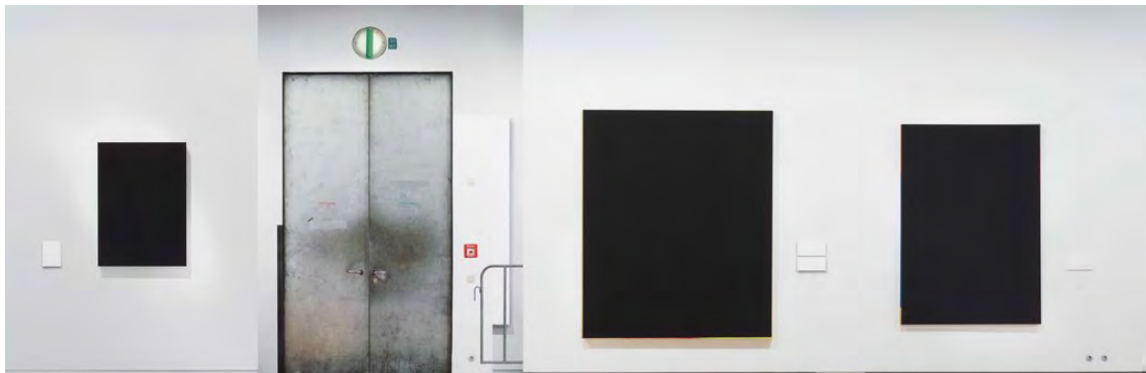


Figure 1

The wall is fabricated to scale with an 'Exit' door included and is so realistic one may feel inclined to touch it to confirm its physicality. This work draws the viewers in by being both perplexing, unsettling and exciting all at once. It is fascinating to be confronted with a manifestation that appears real but is in fact not. It captures our attention and invites us to challenge our assumptions of space and perception. As Kleem (Art Gallery of New South Wales 2015) further explains,

I am concerned with what lies between these areas and how they interrelate.

In 2020 the work was selected for inclusion in an exhibition held at Art Gallery of New South Wales (AGNSW) entitled, *Shadow Catchers* a show which challenges the notion of photography as a documentary art, but rather as a medium which can unsettle and deceive or mislead its audience. For the conservators preparing the work for installation and display, a unique opportunity presented itself to question the notions of reproduction and permanence related to the long-term preservation of works on paper in AGNSW collections. This paper examines:

1. The concepts of re-makeable art in relation to issues of reproduction, availability of photographic materials and technologies and the sustainability of such a practice.
2. The conservator's role in the conservation of this work in preparation for display and draws the conclusion that works of this nature increasingly require conservation staff to take an active role as 'facilitator' (Noordegraaf 2013, p.285) in the actualisation of the work.
3. Contemporary art approaches required to document the iterative nature of the work for future display.
4. The long-term issues surrounding the preservation of digital files which requires unique skills in time-based art conservation to ensure that the work can be preserved and displayed in the future.

Within many museum and gallery environments there is a preference for an artwork to fit into a particular category. It makes it easier to catalogue into a collection database and attribute specialist staff to the care and management of an artwork. However, contemporary art practice is disrupting many of these long-held demarcation and attribution norms. The production medium and the artworks site-specific nature dictates that the work must be destroyed post display. As such, the artist has provided the institution with a still image digital preservation master file for the purposes of re-printing for future iterations. For the artist, the process of refabricating the work each time it is displayed is both a necessity due to the temporary nature of the wallpaper support and an assurance that the work will be given careful contextual consideration for each future display. As such, this work can neither be classified solely as a 'photograph', 'installation' or 'media artwork' – as it is in fact all three. Moreover, the inherent vulnerability of the digital image file and the rapid technological advancement of printing techniques jeopardises both the long-term preservation and re-activation of this artwork, thus requiring expertise in both the fields of paper and time-based art conservation. To prepare the work for display, the collaborative and combined skills of both a Paper Conservator and Time-based art Conservator were employed to holistically address the work. It was determined that both conservation specialities needed to be involved in each step of the object preparation process for documentation purposes.

The first step in the documentation process was to visually inspect all components of the artwork. Paper conservators unrolled the nine sheets that make up the work to undertake a condition reporting activity. During examination, the verso of the work was inspected to gain further knowledge of the adhesive and its activation properties. In conjunction, the paper conservator carried out detailed examination of the paper and ink materials in terms of the reproducibility of

the work in the future, which is heavily dependent on changing printing technologies and commercial wallpaper presentation methods.

Concurrently, the time-based art conservator undertook an in-depth analysis of the digital still image file using the open-source software *MediaInfo* and a detailed inspection of the preserved metadata held within *Adobe Photoshop*. This analysis provided conservators with a detailed list of all the steps undertaken in the creation of a digital file, including any image compression steps that may have occurred in the production process. The results of this investigation ascertained that the Dots per inch (DPI), which is a measure of the resolution of a digital file output in preparation for printing, provided to AGNSW was of a low quality. This posed some questions for conservators in relation to the digital production quality of the files for the current and future wallpaper prints, as a general rule in digital printing is 'the higher the DPI, the sharper the image. A higher resolution image provides the printer and printing device more information. You can get more detail and greater resolution from an image with higher DPI' (Donnellon McCarthy Enterprises 'no date'). Moreover, analysis also indicated that while the file provided to AGNSW was of a .TIFF quality, which is considered an acceptable long-term digital master file format (Digital Preservation Coalition, no date), the file itself had been compressed within Adobe Photoshop. Meaning that it no longer met the required specifications of meeting an 'uncompressed' standard. This raised some further concerns regarding long term viability of the digital file as being of preservation master standard.

This initial inspection determined that more information was required from the artist. Through the combined methods of an artist questionnaire, correspondence, and discussion (INCCA, 2002) key questions posed to the artist were as follows:

1. How and where was the wallpaper made?
2. What materials were used (printing inks, paper etc) to create the wallpaper?
3. What techniques and software were used to create the digital image file?
4. What are the artist's preferred parameters of variability and future display?

To answer the material-based queries, the artist recommended that conservators talk to the printing and production lab used to produce this work, LOOK PRINTING, SYDNEY. Further feedback from the artist suggested the work was very much made in collaboration with the printers. Historically, this is not an unusual partnership for print-based artworks, for example Picasso often collaborated with many printers during his career to produce the highest quality graphic works (Takahatake, 2016). Given this work would need to be remade for future iterations, conservators saw it as important to develop a relationship with the printers to ensure the details and exact specifications for the work were gathered. This involved a site visit.

During the site visit, conservators consulted with a printing technician who confirmed that based on current printing technology standards, the files provided to the AGNSW were not of high enough quality to support future printing requirements. The visit also provided conservators with an in-depth understanding of the commercial printing process and raised some interesting questions around printing companies keeping back up of files for artists, storing master files through their systems, and the arrangements clients make with the printers to either dispose of or keep files for future printing.

During the site visit details surrounding printer specifications and inks used was gathered. Conservators posed questions to the printers around the long-term availability of specific printing materials and equipment to ascertain whether the same printing options would be available for the

next iteration. Due to the nature of commercial printing and the ever-present requirement to improve characteristics such as colour fastness, light sensitivity, and pixel quality, as well as the markets urge to print even larger images for signage and experiment with printing on different surfaces (LOOK PRINT, 2019, pers. Comm., 9 August) it is unlikely that this type of machinery will be available in the long term. The site visits also offered the opportunity to take wallpaper paper samples for testing purposes. It was noted that the paper specifications provided suggested that the paper would perform at its best within 3 years (max shelf life). This was important to note because it meant that for future iterations the work would always need to be displayed within this three-year timeline.

At the conclusion of this visit, the conservation team worked with the artist to secure digital preservation production master versions of the still image file, which would ensure long term preservation of the work and address the printing needs of future iterations for at least the next 5-10 years, depending on how the printing technology evolves. The Time-based art conservator undertook further assessment of the master file to ensure transfer, duplication and ingestion of the digital image file onto AGNSW digital repository for long term storage. It is important to note that all specifications were recorded on the AGNSW collection management database Vernon, and all compiled information such as brochures, product information were saved within the system. Conservators corresponded with the artist post visit and confirmed the artists preference to opt for the 'best printing options available at the time of printing' as a future printing strategy (Geoff Kleem, 2019, pers. Comm., 21 August). Conservators also designed a custom-made questionnaire for LOOK printers to complete, its purpose being to gather all technical information needed for future display of the work.

The documentation stage of the artwork now complete, conservators turned their attention to ensuring preparation of the work and the suitability of the exhibition wall for display in *Shadow Catchers*. At this stage in preparation of the artwork, conservators noted that their role in these activities was evolving into that of a 'facilitator'. As Noordegraaf describes in the 2010 interview with time-based media conservator, Pip Laurenson (p.285),

[increasingly] conservators are working in a professional context, acting as brokers between the artist and the museum in order to facilitate certain technical aspects of integrating works into the collection...

While this may have been the case for last twenty years within contemporary art conservation practice, the remit of the conservator to act as a facilitator in all aspects of an installation has been a progressive shift within more traditional conservation disciplines.

To begin the process of exhibition preparation, the proposed design elevations were drawn up by the AGNSW exhibition team, and in consultation with the LOOK printers the preferred wall specifications were gathered resulting in the wall being suitably rendered and finished with a specified paint to ensure bubbling of the wallpaper would not be a risk. A suitable and safe space to view all 9 sheets of the 11-meter-long work was organised by the conservation team, which involved careful co-ordination and planning. As with all wallpaper works, the sheets were digitally printed to allow for an overlap. Further to examination of the digital file, these overlaps had to be carefully measured and recorded for the purpose of future display, as any misalignment would likely disrupt the impact of the artists carefully constructed image. Due to the large format of this work, pre-display trials and testing of the install procedure was deemed critical in this instance. The Gallery would have one shot to install, and it was crucial that no issues would arise. An experienced wallpaper specialist was asked to examine the prepared wall and do some testing to ensure the wallpaper, which had been printed almost three years prior, still had its adhesive

properties and was not compromised. Unlike other installs of this nature, specialist wallpaper installers were specifically engaged to install the work.

Due to the location of the wall for display (in a public thoroughfare located at the bottom of an escalator) the install began at 5am, which allowed for 6 hrs to install. The role of the paper conservator was to document the process and work with the specialists as required on the floor. Documentation techniques included photography, filming and interviewing the installers throughout the process. The method involved spraying the verso of each sheet to saturate the wheat flour adhesive layer and then carrying the work to its desired location (Figure 2). The sheets were installed one at a time from left to right, with each sheet overlapping the one prior. Given the rate at which wheat flour dries, it was critical to carry the process out quickly, which left very little time for error. Skilled handling and correct placement of each sheet was critical.



Figure 2

Once installed the sheets were carefully trimmed at the edges as per the artists specifications. The sheets were then rolled over with a roller to remove any trapped air bubbled. If this step was missed, any removed blisters would re-appear and cause undesirable lifting overtime. Once installed, visible joins in the image caused by trimming were colour touched with *Gamblin Conservation Colours*, as requested by the artist. Communication with LOOK installers was an essential element in the success of the project, to ensure the wallpaper sheets were at all times treated as ‘artworks’ NOT ‘graphics’. As such, it was essential for conservators to articulate the differences between a Commercial job and an artwork installation – in terms of artist intent and presentation standards to the external team. The installers were meticulous and very respectful of the process, including the need for extensive documentation and record taking (Figure 3). The installers provided feedback to conservators that, ‘this was very rewarding experience for them to be involved in the installation of such a work’ (LOOK PRINT 2020, pers. Comm., 22 February). To support future of display artwork, conservators were required to use documentation techniques commonly used in time-based and contemporary installation art conservation, such as iteration reporting (Phillips 2015) and the creation of step-by-step instruction manuals using iPad and apps such as Notability. These methods are becoming more and more common in the conservations tool kit.

The work was displayed for four months and under the instruction of the artist it was to be destroyed upon removal. In support of the artists wishes, the Conservation team had to ensure the work was indeed destroyed post display, an unfamiliar concept indeed for a conservator trained to preserve physical objects as a key priority.

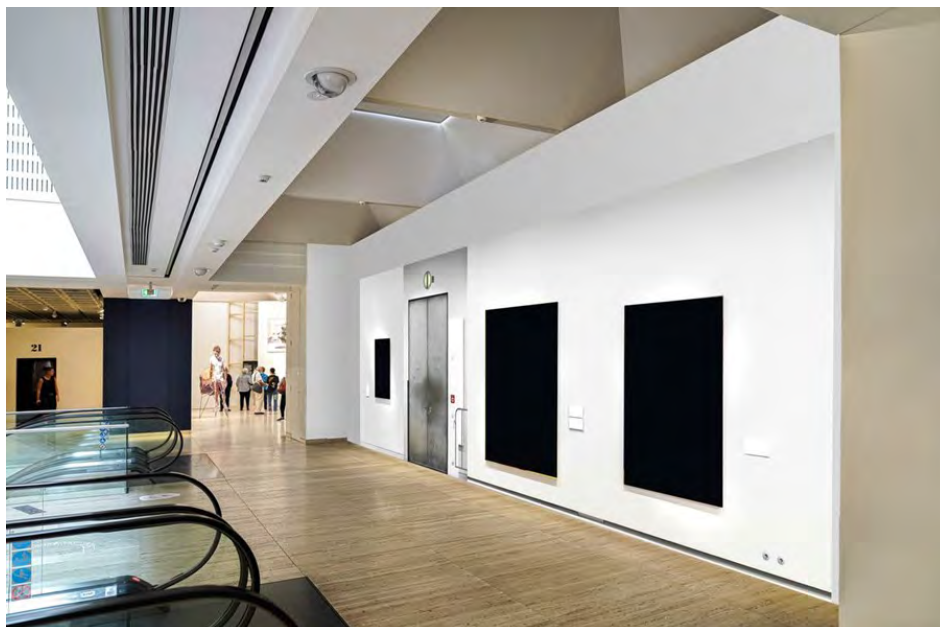


Figure 3

Conclusions

This project raised many new considerations for the conservators involved in the long-term preservation and installation of this complex wallpaper work. The authors agree that working with contemporary artists and artworks can be both a challenging and rewarding process. Contemporary artworks challenge the traditional tenants of conservation in terms of minimal invention, reversibility, long term preservation and the notion of the conservator as impartial (Van Saaze, 2013). This work in fact required both the paper and time-based art conservators be active participants in both the preservation, display and future re-reproducibility of the artwork. It was a significant and productive collaboration between paper and time-based art conservator, as the nature of the work meant that activities were shared between the two specialities. In this instance, the time-based art conservator focused on the preparation of the digital files and facilitating the transfer of digital files between LOOK and the gallery, as well as ensuring the long-term preservation of digital files, so the work can be reproduced in the future. Whereas the role of the paper conservator dealt with a lot of the practicalities around presenting the work for display, acting as facilitator between LOOK, the artist, and the gallery to ensure that the work was accurately presented. The specialisation of time-based art conservation, which has an in depth understanding of digital preservation, is an emerging area in the conservation field, but is becoming more relevant as artists are continuing to use digital technologies to create artworks. The opportunity to collaborate across specialisations ensured that AGNSW could address all aspects of the work to ensure its future.

Acknowledgements

The authors would like to acknowledge Geoff Kleem, Isobel Parker Philip, LOOK Printing Team and the wonderful Collections Team at the Art Gallery of NSW.

Authors Biography

Analiese Treacy

Analiese Treacy is a Paper Conservator at the Art Gallery of New South Wales, where she has worked since 2006 caring for works of art on paper and photographic material. Analiese is an active member of the Australian Institute for the care of Cultural Material (AICCM) presenting regularly at the Book, Paper and Photographic Materials Symposiums and National Conferences. Prior to working at the AGNSW, Analiese has had the opportunity to work at several cultural institutions including the National Gallery of Ireland, Museum Boijmans Van Beuningen (Holland), Bowes Museum (UK), Trinity College Dublin, Museum Victoria, State Library NSW, Australian National Maritime Museum, and the Powerhouse Museum. Analiese holds a joint Honours Degree in Art History and Italian from University College Dublin, and a Masters Degree in Fine Art Conservation from the University of Northumbria, Newcastle, England. Contact: analiese.treacy@ag.nsw.gov.au.

Asti Sherring

Asti Sherring is a paper, photographs and time-based art conservator. She has completed a Bachelor of Media Arts from Sydney University and a Masters of Materials Conservation at Melbourne University. Previously Asti held the position of senior time-based art conservator at The Art Gallery of New South Wales between 2015 - 2020. This role was the first of its kind in Australia and focused on the development of the specialisation of time-based art conservation across Australasia. She has also worked at notable institutions such as The University of Newcastle, Los Angeles County Museum of Art, USA, The 20th and 21st Biennale of Sydney, The National Archives of Australia and Museum of Contemporary Art, Sydney. Asti is currently undertaking postgraduate research at the University of Canberra, which explores contemporary conservation theories and practices surrounding the preservation of works that are virtual, ephemeral, immersive, participatory, and technology based.

Bibliography

Art Gallery of New South Wales 2015, Website, accessed on 12th May 2021 from:
<<https://www.artgallery.nsw.gov.au/collection/works/408.2015.1/>>

Clement, T. 2016 'Kleem getting lost and found in the forest'. *Art Collector issue 77, JUL–SEPT 2016* accessed on 7th May from: <<https://artcollector.net.au/geoff-kleem-getting-lost-and-found-in-the-forest/>>

Digital Preservation Coalition, no date, Website, accessed on 14th May 2021 from:
<<https://www.dpconline.org/handbook/technical-solutions-and-tools/file-formats-and-standards/>>

Donnellon McCarthy Enterprises 'no date', Website, accessed on 12th May 2021 from:
< <https://www.dme.us.com/2018/12/11/what-is-dpi-and-what-are-the-requirements-for-different-industries/>>

INCCA (2002). *Guide to Good Practice: Artists Interviews*, accessed on 7th May 2021 from
<http://www.incca.org/files/pdf/resources/guide_to_practice.pdf>

Kleem, G. 2016, 'Getting Lost and Found in the Forest', *The Art collector*, Issue 77 July-Sept, accessed on 15th May from <<http://geoffkleem.com/texts/geoff-kleem-art-collector.pdf>>

Noordegraff, J. (2013), 'The conservation of media art at the Tate. An interview with Pip Laurenson (Head of Time-based media conservation at the Tate)' pp.282 – 287 in Saba, B Le Maitre, & V Hediger (eds), *Preserving and Exhibiting Media Art*, Amsterdam University Press, Amsterdam

Phillips, J., 2015. 'Reporting Iterations: A Documentation Model for Time-Based Media Art'. In: L. Matos, R. Macedo and G. Heydenreich, ed., *Performing Documentation in the Conservation of Contemporary Art*. Lisbon: Instituto de Historia da Arte, pp.168-179.

Takahatake, N. 2016. 'The Art of the Printer', *LACMA Unframed*, Nov 7th 2016. Accessed 7th May 2021 from: <<https://unframed.lacma.org/2016/11/07/art-printer>>

Van Saaze, V. (2013). 'Key Concepts and Developments in Conservation Theory and Practice'. In *Installation Art and the Museum: Presentation and Conservation of Changing Artworks* (pp. 35-60). Amsterdam: Amsterdam University Press. Accessed 7th May from: <<http://www.jstor.org/stable/j.ctt46n18r.5>>

Hyperspectral Imaging applied to the study of negative and positive films

Marcello Picollo, Costanza Cucci, Andrea Casini, Lorenzo Stefani

Istituto di Fisica Applicata “Nello Carrara” del Consiglio Nazionale delle Ricerche (IFAC-CNR),

Via Madonna del piano 10, 50019 Sesto Fiorentino, Firenze (I)

Contact: Marcello Picollo, m.picollo@ifac.cnr.it

Abstract

Hyperspectral imaging technique, well established in the art conservation field, was applied for the first time on contemporary negative and positive films within the Tuscan Region (Italy) and IFAC-CNR Florence (Italy) “Memoria Fotografica” (Photographic Memory, 2018–2019) project. In this project, different classes of photographic materials (color negatives, color slides, prints with chromogen and inkjet development), that were severely compromised by a dramatic flood, were studied. The acquired HSI data were processed in order to obtain information on the state of conservation of the color negative film, to support with accurate spectroscopic information the digitalization phase and the subsequent digital restoration of the photographic materials.

Keywords: hyperspectral imaging, color films, Memoria Fotografica, UMAP.

Introduction

In the cultural heritage field, imaging techniques, including X-ray, raking light, fluorescence induced by ultraviolet radiation, photographic infrared, reflectographic infrared and false color infrared, are commonly used for the study of artistic artifacts to follow both the documentation and diagnostics of the studied artworks (Warda et al., 2011). In recent years, the emergence of imaging spectroscopy (IS) techniques has allowed to combine the concept of 'diagnostic technique' with that of 'analytical technique' thanks to the acquisition of spectroscopic data, suitable for the identification of the materials (pigments, dyes, restoration materials, products of alteration, etc.) on the artwork (Fischer and Kakulli, 2006; Cucci et al., 2016).

Among the IS techniques, the hyperspectral imaging (HSI) systems are based on the acquisition of hundreds of images (cube-image or cube-data) in narrow (<10 nm) and contiguous spectral bands. This implies that the data obtained have a spectral resolution comparable to that of laboratory instruments. Processing the data cube allows compositional information to be obtained, making it possible to map the distribution of compounds and / or compositional / textural differences.

For over a decade, numerous studies and research projects have been dedicated to adapting the instrumentation for image spectroscopy to the specific needs of conservation and restoration of Cultural Heritage objects. This technique has now reached the stage of technological maturity and is now usable for the investigation of various types of planar objects (2D), such as paintings on mobile support, mural, paper, parchment, etc., both with instruments made by specialized companies and, in very rare cases, with devices developed ad hoc in research laboratories.

The measurements acquired for this study were performed with a high-resolution spatial and spectral HSI scanner made at IFAC-CNR that allows operating non-invasively on surfaces of variable dimensions and supports (Casini et al., 2005). In particular, for the study of 35 mm photographic negatives and positives, it was set up a prototype optimized for this type of materials by modifying the optics and the lighting system in origin designed to operate on painting in reflectance mode, with consequent readjustment of the data acquisition procedures.

IFAC-CNR Hyperspectral Imaging Scanner

In order to investigate photographic negatives the IFAC-CNR HSI device had to be re-designed for this purpose (Fig. 1). The hyperspectral scanner for transmission measurements on photographic material consists of a spectrograph linear connected to a camera, by a mechanical part that allows the movement of the clips of photographic film, from a projector that uniformly illuminates a diffusing

screen positioned almost a contact of the sample to be measured. The scan is obtained by moving the object to be measured in front of the measuring head, and the acquisition takes place by horizontal swipes. In this spectral scan scheme, the line segment runs orthogonally along the scan direction. Before each scan, horizontal calibration is performed on the illuminant itself. Lighting is provided by a lamp tungsten-quartz halogen (QTH) of 150 Watts with a color temperature of approximately 3200 K. The scan has a spatial sampling step of approximately 37 microns (~ 27 samples per millimeter, equivalent to nearly 700 ppi). The images produced have a spatial resolution of 5 lines per mm, calculated at half of maximum contrast using a special calibration target. The spectral resolution results ~ 2.8 nm, with ~ 1.2 nm step spectral sampling yielding 400 bands in the operating range from 400 to 900 nm.



Fig. 1 - Overview of the IFAC-CNR imaging spectroscopy instrumentation set up for measurements on negative and positive 35 mm films.

Data Processing Procedures

For the spectroscopic study of these films, it was decided to use a multivariate analytical approach developed for the treatment of large amounts of data. This made it possible to obtain a separation into homogeneous classes of areas, or better pixels, having spectral trends similar to each other. This phase of the research was aimed at testing a series of algorithms and procedures to define these classes. In particular, among the various algorithms developed and tested in recent years, it was decided to use a new statistical approach for the separation of pixels according to the mathematical model defined UMAP (Uniform Manifold Approximation and Projection for Dimension Reduction) (McInnes et al., 2018). The UMAP procedure allows us to view the elements (pixels) that make up the area of interest (ROI) grouped by the proximity of their trend spectral. Although the program used currently provides projected results only on a plane (2D), the aggregations of data in proximity spectral classes were found to be more clearly identifiable than those obtained with other statistical - multivariate methods. Although still at an exploratory level, this study has provided indications on the potential use of HSI technique to support the digitization and digital restoration of the frames. In particular, it was found that the hyperspectral data could be used to understand if and to what extent the dyes in the emulsions have retained their original characteristics or have undergone alterations due to their natural aging or particular events. In principle, the data thus obtained can also be used to guide the digitization of the frames and their subsequent digital restoration. Furthermore, the HSI application to the class of photographic materials can be summarized in the fact that this technology can play a leading role in long-term conservation, in the documentation and cataloging of the material collected in archives and photographic collections (Trumpy et al., 2015).

Conclusion

To the knowledge of the authors, HSI technique has been applied to the study of negatives photography for the first time in this project. The development of an optimized system for the investigation of photographic material has opened a new application perspective. In addition, it was necessary to rethink the part of data processing according to the type of material analyzed. At this point, it is believed that the methodology is ripe for use in the specific sector, thanks to the ability to

provide data and information useful for defining the spectral characteristics of the dyes of the emulsions even in the presence of an advanced degradation of the material. In particular, it looks like a promising one methodology to be used to support conservation and restoration interventions. With the acquired data, it is possible to obtain a map of the distribution of the various levels of 'impression' of the mixture of dyes, defects and gaps on the frame.

Bibliography

- Casini, A. Bacci, M. Cucci, C. Lotti, F. Porcinai, S. Picollo, M. Radicati, B. Poggesi, M. and Stefani, L. (2005) 'Fiber optic reflectance spectroscopy and hyper-spectral image spectroscopy: two integrated techniques for the study of the Madonna dei Fusi', in "Optical Methods for Arts and Archaeology" –Aug. 2005 Proc. SPIE Vol. 5857, p. 177-184 R. Salimbeni, L. Pezzati Eds.
- Cucci, C. Delaney, J. K. and Picollo, M. (2016) 'Reflectance Hyperspectral Imaging for Investigation of Works of Art: Old Master Paintings and Illuminated Manuscripts', *Acc. Chem. Res.* 49, 2070–2079.
- Fischer, C. and Kakoulli, I. (2007) 'Multispectral and Hyperspectral Imaging Technologies in Conservation: Current Research and Potential Applications', *Reviews in Conservation* 7, 3–16.
- McInnes, L. Healy, J. and Melville, J. (2018) *UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction*, arXiv:1802.03426v2 [stat.ML] 6 Dec 2018.
- Trumpy, G. and Flueckiger, B. (2015) 'Light source criteria for digitizing color films', 2015 Colour and Visual Computing Symposium (CVCS). 978-1-4799-1765-5/15/\$31.00 ©2015 IEEE.
- Warda, J. Frey, F. Heller, D. Vitale, T. and Weaver, G. (2011) *The AIC Guide to Digital Photography and Conservation Documentation*. Edited by Warda. 2nd ed., American Institute for Conservation of Historic and Artistic Works, Washington, DC.

BRITTLE MEMORIES. Case study of a broken photographic crystoleum

Viviana Goggi¹, Martina Trento²

¹Soseishi snc, paper and photograph conservation, private practice, Turin (Italy)

²metal and glass conservation, private practice, Turin (Italy)

Contact: Viviana Goggi, info@soseishi.com

Abstract

Many times photograph conservation questioned as to the best methods to consolidate and repair broken photographs on glass. The purpose of this case study is to share a treatment option the authors carried out on an example of a positive image on convex glass: a broken photographic crystoleum.

The object is a cabinet portrait of Antonina Capece Minutolo, princess of Collereale, made by Bettini Studio in Livorno around 1880 and kept by her family. Mounted in a frame in wrought brass, photograph has been broken by accidental events. Most of fragments have been recovered, but both glasses showed overall losses of support in addition to breaks. Checked the stability of the emulsion of albumen print, best solution to preserve object and to give back a correct reading of portrait was to rejoin the fragments with an epoxy resin. This resin is very strong and it can be applied on glass side by wicking. Capillarity action pulls the required amount of adhesive into the interface, without coming emulsion side, and with minimal excess on application side. Any residues can be removed, after drying, with a small amount of solvent. Resin does not interfere with the transparency of support, and low shrinkage reduces creating of distracting dark lines when viewed with transmitted light. As is usually done in glass conservation, the same resin has been used as well to fill losses and the possibility to be coloured proves to be a good solution for a stable retouching of image.

Keywords: crystoleum, convex miniature, glass, epoxy resin

Introduction

When you come across an object reduced to fragments, first impulse is to put together puzzle. This is more pressing when the object contains an image that otherwise it cannot be read.

For negative plates, which are the most representative photographic objects on glass, it can be solved refitting in proper order the fragments that can be scanned or printed via traditional in a darkroom to have a visual record of what is on these plates. After scanning, the pieces can be placed in sink mats that keep the glass from moving and greatly reduce the chance of further breakage.

Unfortunately, it proves to be not so successful procedure to (con)serve positive images, and even less on convex glass like a crystoleum. Indeed, image would still remain illegible, and it would be very complicated to keep the glass from moving.

The treatment carried out tried to solve these issues, proposing a solution to reassemble fragments recovering image and stabilizing the object, especially since it is a part of a family collection and it is kept in a private house.

The crystoleum

This term - from “crystal” and “oleum” (oil) - is used to describe a type of hand-painted photographs mounted on glass in imitation of ivory and porcelain painting.

The crystoleum process was popular from 1880's until 1910's and was usually an albumen print face-mounted to convex glass with gum or paste. The paper support is then rubbed away with sandpaper until the emulsion layer is exposed. What was left of the paper was made translucent, if needed, with a dry oil, wax or varnish. Fine details were then painted on the back of the photograph using oil paints. A second piece of convex glass with larger areas of painted colours (usually oil-based) is layered behind the image glass, then the package is bound with a paper or a cardboard backing. The process was derived from 18th century mezzotint process and allowed to create a detailed and sharp image.

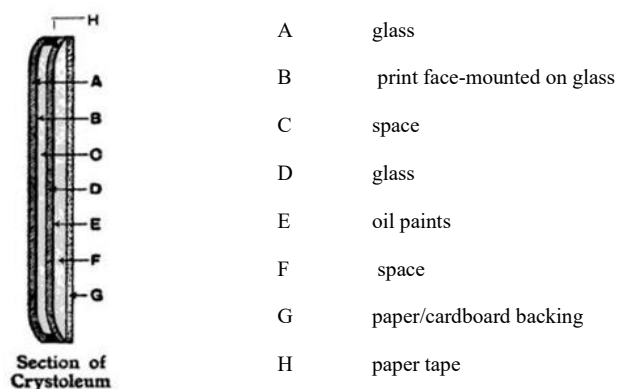


Fig. 1 – anatomy of a crystoleum

The object of this case study is a cabinet portrait of Antonina Capece Minutolo, princess of Collereale, kept by her family.

Naked eyes observation and under microscope confirmed it's an albumen print.

Thanks to trademarks on cardboard backing we know it was made by Bettini Ugo in Livorno probably between 1875 and 1900, time when the photographer had his studio at Ricasoli Street. However hairstyle and clothing place the image around 1880.

Mounted in a frame in wrought brass, photograph has been broken by accidental events.

When portrait arrived in our lab, it was 42 fragments (Fig. 2, 3). Most of fragments have been recovered, but both glasses showed overall minor losses of support in addition to breaks. The result was that portrait was almost unreadable.



Fig. 2 – before treatment



Fig. 3 – before treatment

Treatment

1. Open the package:

Sealing red gum paper tape has been removed by means of idrogel High Water Retention Nanorestore[®] (Fig. 4, 5).

Checked the stability of the emulsion and of the oil painted layers, best solution to preserve object was to reassemble fragments.



Fig. 4 – application of HWR Nanorestore idrogel



Fig. 5 – removing of sealing paper tape

2. Assemble glasses:

The shards were assembled with the aid of a lightline and held in place with masking tape. Before each placement, the fracture line of each shard was swabbed with an etanol soaked swab and inspected to ensure that the shard-fracture was as clean as possible (Fig. 6).

Once all fragments were perfectly aligned, we secured them with cyanoacrylate drops and left to dry (Fig. 7, 8).

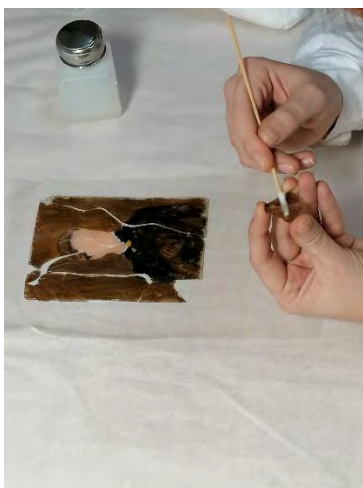


Fig. 6 – shards cleaning



Fig. 7 – fragment assembling with masking tape



Fig. 8 – cyanoacrylate drops

3. Wick in adhesive:

Epoxy resin for glass commercially known as Kristal Fluid was wicked into the fracture interfaces using a steel or wood swab as an applicator. Once the adhesive was fully applied, the glass was left undisturbed overnight (Fig. 9, 10).

We preferred epoxy to acrylic resin, as Paraloid B72, to avoid as much as possible solvent input on object and reduce risk of reaction with oil and wax based substances. Both resins are very strong, and they can be applied on glass side by wicking. Capillarity action pulls the required amount of adhesive into the interface, without coming emulsion side, and with minimal excess on application side. But to wick into the fracture interface Paraloid B72 should be at 20% maximum; it means high amount of solvent on photographic and painted layer over application and after when the solvent evaporates to leave sufficient solids to form adhesive bond. It does not happen with epoxy that hardens thanks to the cross-linking reaction between two viscous substances (resin and a co-reactant).

The particular composition and purity of Kristal Fluid, the presence of special anti-foam and anti-bubble, as well as UV resistant fillers, allow to not interfere with the transparency of support over time. Furthermore, low shrinkage reduces creating of distracting dark lines when observed by transmitted light.



Fig. 9 – epoxy resin preparation



Fig. 10 – epoxy resin application

4. Clean the glass side of plate:

Once the adhesive was fully cured, cyanoacrylate drops and epoxy resin remains were removed with a heated scalpel and acetone swabs (Fig. 11, 12).



Fig. 11 – removing remains with heated scalpel



Fig. 12 – removing remains with swab

5. Fill losses:

The same resin was used to fill overall losses on both glasses. As is usually done in glass conservation, to make a properly fitting inlay on glass we created a sort of mold using dental modelling wax (Fig. 13, 14). Small pieces of wax sheet were gently manipulated and applied directly onto each loss on glass support side with a heated scalpel. Low melting point and transition temperature of wax sheets minimize stress relief and allow easy manipulation to conform to the contours of loss.

Resin was then applied inside mold using a steel or wood swab drop by drop (Fig. 15). Once it was fully dried, wax mold has been removed with a heated scalpel.

We chose to use glass paint (Glassart Marablu®) coloured resin to imitate colour homogeneity of glass with albumen print (Fig. 16). Instead for painted glass we used transparent resin later retouched with watercolours (Fig. 17,18).



Fig. 13 – dental modelling wax sheet



Fig. 14 – wax mold



Fig. 15 – epoxy resin application



Fig. 16 – glass painted coloured resin fill



Fig. 17 – transparent resin fill



Fig. 18 – watercolour retouching

6. Consolidate paper supports:

We cleaned cardboard backing with Magic Rub gum (Fig. 19). and we consolidated sealing red gum paper tape with Japanese paper (Kami, W5, 100% kozo, 18 g/sm) and Zin shofu paste (Fig. 20,21).



Fig. 19 – cardboard cleaning



Fig. 20 – sealing tape consolidation

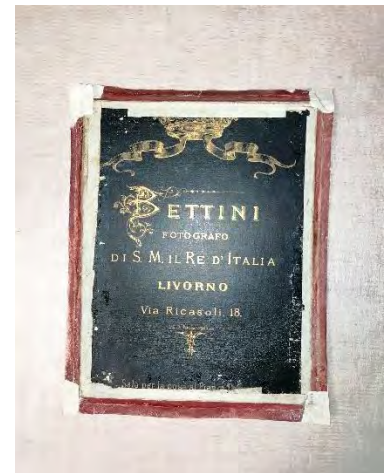


Fig. 21 – sealing tape consolidation

7. Seal package:

We remounted glasses on cardboard, sealed package pasting the original tape with acrylic resin and retouched abrasions and paper inlays on it with watercolours (Fig. 22,23).



Fig. 22 – package sealing



Fig. 23 – watercolour retouching

Conclusion

The procedure has proved very successful. Use of epoxy resin not only to rejoin fragments but also to fill overall losses allows to consolidate each glass separately facilitating handling and mounting one over the other on cardboard. Furthermore, the possibility to colour the resin offered a good solution to imitate colour homogeneity of albumen emulsion on glass.

After treatment the portrait results readable, perfectly stable and safely handling.

Bibliography

Caspar, Alberta (1883) *Crystoleum: including all the improvements and practical instructions for acquiring this popular art perfectly, with full information on the method of mixing and applying the colors. Together with a description of émail vitré, the new water-color enamel, crayonium, the wonderfully easy system of drawing and terroleum, the new system of modelling*, London : Caspar's Original Crystoleum Company

Jones, B.E. (1911), *Cassel's cyclopedia of photography*, London : Cassel and Company ltd.

Chiesa and Gosio , (2013) *Dagherrotipia, ambrotipia, ferrotipia positivi unici e processi antichi nel ritratto fotografico*, IT: Youcanprint

Whitman and Wiegandt, 'Case Study: Repair of a Broken Glass Plate Negative, *Topics in Photographic Preservation, Volume 12* (2007), pp: 175-181