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International scientific conference

Colour in written heritage - multidisciplinary research

Zagreb, 25 – 27, September 2024.

FOREWORD

Colour and written heritage are two separate concepts that intertwine to shape the context, content and appearance of objects of historical, cultural and artistic value. The first appearance of colour in written heritage is characterized by simplicity, however, in the course of time it evolved into an element that serves a specific purpose, such as to emphasize and highlight content. In this context, the impact of colour on the understanding of the content of written heritage is indisputable.

Colour can be defined as electromagnetic radiation of the visible part of the spectrum, which completes our psychophysical experience. Colour conveys certain information, symbolism, but also emotion and story. Knowledge of colour theory, psychology and cultural aspects undoubtedly contributes to understanding the significance and content of written heritage. The result of such an approach is a comprehensive understanding of the significance, richness and diversity of the content of written heritage, which reflects the diversity of history recorded through the written and printed word and image. Multidisciplinary research into colour in written heritage creates a comprehensive approach, which makes it possible to understand and appreciate cultural, historical and aesthetic values more deeply. It is precisely the breadth and diversity of such research that is in the focus of the international scientific conference "Colours of Written Heritage - Multidisciplinary Research".

PROGRAM

Day 1

25 September 2024.
Croatian State Archives,
Trg Marka Marulića 21, 10 000 Zagreb

PROGRAM

9.00
Registration

9.30
Welcome speech

9.45 - 10.30

Hana Breko Kustura
Croatian Academy of Sciences and Arts
Neumes and colors in the medieval chant book

Ines Horvat [1], Jasmina Lukinac[2], Damir Hasenay [1]
[1] Faculty of Humanities and Social Sciences Osijek, [2] Faculty of Food Technology Osijek
Document Image Analysis: Potentials, Applications and Beyond

Višnja Bralić
Ministry of Culture and Media
How the stylistic analysis of the miniatures in Rovinj Illuminated Codex can helps specify its date and provenance

10.30

Crescat
Crescat, Zagreb
Crescat company - Product presentation

10.40
Discussion

11.00
Coffee break

11.30
Exhibition opening „ Projekt Bunker“

12.00 - 12.45

Sanja Cvetnić
University of Zagreb Faculty of Humanities and Social Sciences
Painting a Rosy Picture: Female Saints in Illuminated Glagolitic Manuscripts

Péter Ekler
National Archives of Hungary, Budapest
Coats of arms of bibliophile bishops and archbishops (Kingdom of Hungary, second half of 15th century)

Jasna Malešič [1], Irena Kralj Cigić [2]
[1] National and University Library, [2] University of Ljubljana, Faculty of Chemistry and Chemical Technology
Color Stability of Verdigris Pigment on Paper Support

12.45
Discussion

13.00
Lunch

13.45
Tour of the representative spaces of the Croatian State Archives

14.15 - 15.00

Sami Arslan [1], Tatjana Paić-Vukić [2]
[1] Fatih Sultan Mehmet Vakif University, Istanbul, [2] Croatian Academy of Sciences and Arts, Zagreb
Coloured paper and ink in Islamic manuscripts

Siniša Prugovečki [1], Emilia Plukavec [2], Andreja Dragojević [3]
[1] Metroteka d.o.o. , [2] Metropolitan library of Zagreb Archdiocese - Croatian State Archives, [3] Croatian State Archives
Temperature and relative humidity mapping in spaces containing moveable cultural heritage

Iva Gobić Vitolović
State Archives in Rijeka
Inpainting or visual compensation methods on written heritage – case studies from the State Archives in Rijeka

15.00
Discussion

15.15
End of the first conference day

Day 2

26 September 2024.
Archdiocese of Zagreb
Archdiocesan Pastoral Institute,
Kaptol 29a, 10 000 Zagreb

PROGRAM

9.00
Registration

9.30
Welcome speech

9.45 -10.30

Mirjana Jurić
Croatian State Archives
Cartography and Colours in the Croatian State Archives

Jelena Duh
National and University Library in Zagreb
Painted incunabula in the Manuscripts and Old Books Collection of the National and University Library in Zagreb

Sonja Jamnicki Hanzer
University of Zagreb, Faculty of Graphic Arts
The Evolution of Printing Inks: From Ancient Formulations to Modern Innovations

10.30
Discussion

10.45
Coffee break

11.15
Exhibition opening „Glavačeva karta“

11.45 - 12.30

Jedert Vodopivec Tomažič
AlmaMater Univerza, EC Maribor
From milky white to nearly chestnut brown paper

Vladan Desnica
Academy of Fine Arts, Zagreb
Multi-analytical research on colour in written heritage - case studies at the Academy of fine arts in Zagreb

Ladislav Dobrica, Andreja Dragojević
Croatian State Archives
Color & dignitas – the use of colours in the appointment to the banal dignity of Petar 4th Zrinski in 1665.

12.30
Discussion

12.45
Lunch break

14.00 - 15.30
Panel discussion
Multidisciplinary research of written heritage - challenges and application

16.00
Tour of the Cathedral sacristy and Treasury

17.00
End of the second conference day

Day 3

27 September 2024.
University of Zagreb Faculty of Graphic Arts,
Getaldićeva 2, 10 000 Zagreb

9.00
Registration

9.30
Welcome speech

9.45 - 10.30

Tomica Plukavec
Archdiocese of Zagreb, Archdiocesan offices, Office for culture
Coloured print of the Diocesan Museum Archdiocese of Zagreb

Milena Martinović
National Museum of Montenegro-Cetinje
Role and importance of microbiological and chemical testing conducted on books from the "Petar II Petrović Njegoš" library of the Njegoš Museum – Biljarda

Emilia Plukavec
Metropolitan Library of the Zagreb Archdiocese, Croatian State Archives
Illuminated manuscripts

10.30
Discussion

10.45
Coffee break

11.15 - 12.15

Andreja Dragojević
Croatian State Archives
Blue Paper: History and composition

Jelena Macan [1], Andreja Dragojević [2]
[1] University of Zagreb Faculty of Chemical Engineering and Technology, [2] Croatian State Archives
Spectroscopic investigations of historical and modern blue papers

Maja Strižić Jakovljević
University of Zagreb, Faculty of Graphic Arts
The Colours of Written Heritage and Contemporary Papers

Sanja Serhatlić , Danijela Jemo
University of Dubrovniku
The Hidden Blue of the Graduals from Badija

12.15
Discussion

12.30
Lunch

13.30 - 14.15

Alan Divjak [1], Vladimir Cviljušac [2], Damir Modrić [3]
[1] Algebra University, Zagreb , [2] University of Zagreb Faculty of Graphic Arts, [3] University North, Koprivnica
Mechanical design of a 120-band hyperspectral imaging system

Damir Modrić
University North, Koprivnica
Hyperspectral camera as a spectrometer in the preservation of written and printed historical materials

Vladimir Cviljušac
University of Zagreb Faculty of Graphic Arts
Analysis of the spectrum of illuminations in books from the 14th and 15th centuries obtained with a hyperspectral camera

14.15
Discussion

14.30 – 15.30

Tour of the Laboratory for graphic materials
Workshop on Multispectral Imaging in cooperation with the Museum of Contemporary Art – Zagreb and Croatian State Archives

15.00
End of the conference

ABSTRACTS

Neumes and colours in the medieval chant book

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The aim of this paper is to show the importance of colour in medieval musical manuscripts, and their role in detecting provenance and target destination (church) which a certain musical manuscript was compiled for.
As a case study, the oldest missal written for medieval Pula was chosen. This chant book was written in the famous Benedictine monastery of Tegernsee in Bavaria around 1050. It is the oldest musical manuscript of medieval Istria, but also the oldest preserved musical codex of the wider area of the Aquileian Patriarchate, which contains the repertoire of the first European musical author - Notker from Sankt Gallen (+912).
What is the mutual relationship between neumatic signs, (i.e. the musical notation) themselves and the colours that surround them on a particular parchment sheet, and in what way exactly the colour of the tendril initials was a "signal" for the discovery of the true provenance of this important Croatian musical mass codex from the 11th century – this is what we will try to find out in the visual and audio presentation that accompanies this paper.

Keywords: The oldest missal of Istria, Tegernsee, sequence, Notker, illuminations.

Document Image Analysis: Potentials, Applications and Beyond

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Document Image Analysis (DIA) is a powerful approach used to analyse visual content in various fields. Regarding its use in the preservation of written heritage, DIA enables insight into various characteristics and properties of a document. Combined with different ways of image acquisition and analysis, it enables a number of possibilities in the research of preservation of written heritage. DIA coupled with microscopy enables researchers to perceive document elements on microscopic level and subsequently analyse them more thoroughly. Considering that typography is at the same time a textual and a graphic element, techniques such as mean grey value analysis and structural similarity facilitate the quantitative assessment of typefaces, including colour, contrast, and structure, thus providing insights into both universal structures and specific attributes.
In this study DIA was applied in the analysis of typographic characteristics of different fonts. Microscopic photographs of samples were captured using an Olympus BX51 microscope with a DP25 digital camera. The aim was to employ the DIA and possibilities of segmentation methods to establish a certain methodological path to select appropriate pre-processing techniques and optimal image segmentation methods in order to objectively analyse the acquired samples. This included the choice of the most appropriate and most effective threshold method which could be used for segmentation and further analysis of these samples. The goal of the proposed methodological path is to enable the application of DIA as an objective and repeatable way to analyse typographic characteristics, providing valuable insights into typeface specificities, such as size and shape descriptors, which include circularity, area, roundness, solidity etc.
As a method, DIA allows objective research of written heritage, paving the way for its application beyond the analysis of text and graphic elements.

Keywords: Typography, Document Image Analysis, Typeface Classification

How the stylistic analysis of the miniatures in Rovinj Illuminated Codex can helps specify its date and provenance

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The Rovinj Illuminated Codex (*Translatio corporis beate Eufemie*), the main hagiographical source for the saint co-patron of the city, was tentatively dated to the 13th and 14th century as a work of a Venetian scriptorium. This is mainly based on analysis of the contained texts written in the Gothic minuscule rotunda. Despite the publication of a facsimile in 2000, the miniatures in the Rovinj Illuminated Codex did not trigger any further art historical research.
In this presentation we will explore how the comparative analysis of stylistic and artistic features of the miniatures (fol. 6r – 23r) helped determine the period, authorship and context of its creation, shedding a new light on the role of the Venetian officials in the promotion of the cult of St. Euphemia. The manuscript can be dated to the last quarter of the 15th century and is attributed to a Venetian miniaturist known as the Master of the Pico Pliny (Pico Master). Diversity and quantity of works attributed to the miniaturist so far indicate involvement of multiple assistants of the workshop. In addition, our research of miniatures in the Rovinj Illuminated Codex has facilitated the identification of additional illuminated manuscripts by the same author and his workshop, such as the *Antiphonale de Sanctis* E from the Franciscan monastery in Dubrovnik.

Keywords: Master of the Pico Pliny, Pico Master, Rovinj Illuminated Codex, *Translatio corporis beate Eufemie*, *Antiphonale de Sanctis E*

Painting a Rosy Picture: Female Saints in Illuminated Glagolitic Manuscripts

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There is significant diversity in how colours and their connotations are used across different cultures and within the same culture over different time periods. Although the same colour can have vastly different meanings within the same culture at different times, it is quite standardised in Christian iconography throughout the centuries. Research on female figures in Glagolitic manuscripts between the 14th and the 16th century provides particular insight into the iconography of colours in this modestly researched corpus of illuminations in Croatia. Standardised colour symbolism in the history of art, Christian liturgy, theology, and visual communication helps convey the hagiographical connotations related to particular saints (such as red garments for martyrs) and also contributes to storytelling. In the case of female saints, colours have an additional task: to create graceful figures with delicately painted garments that enhance their saintly femininity. The Blessed Virgin Mary is easily recognisable in various iconographical situations involving other figures (Nativity, Visitation, Crucifixion, Pentecost) by either a blue mantle over a red robe or, less often, a red mantle over a blue robe. These colours not only serve as identifiers but also have other meanings, revealing among other connotations Virgin Mary as the Ark of the New Covenant. In the Old Testament, the Ark of the Covenant was covered with "a cloth of solid blue" (Num 4:6).

Keywords: female saints, iconography of colour, Glagolitic manuscripts

Coats of arms of bibliophile bishops and archbishops (Kingdom of Hungary, second half of 15th century)

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Two years ago we gave a lecture (The Seals of Johannes de Zredna and His Coat of Arms in Illuminated Codices) at a conference in Zagreb (English title: Ivan Vitez – Slavonian nobleman, canon of Zagreb, Hungarian primate and a promoter of humanism, held in Zagreb, 16. September 2022).
Researchers (e.g. Csaba Csapodi, Ferenc Földesi, Dániel Pócs, György Rácz, the author of this abstract and others) have been interested in this question ever since. A research on the coat of arms of Johannes de Zredna (= Ivan Vitez) can be extended to other individuals as well.
In our presentation we will introduce the following distinguished personalities and their coats of arms: John, Bishop of Pécs, ban of Slavonia (= Janus Pannonius); Urban Nagylucsei, Bishop of Győr, Bishop of Eger; Peter Váradi, Archbishop of Kalocsa; and Dominic Kálmáncsehi, Bishop of Várad.
We also aim to present the seals of these ecclesiastical dignitaries.
At the same time, we will present the illuminated codices in which these coats of arms can be seen.
The above-mentioned dignitaries were educated figures in the time of King Matthias.
Learning about their activities will lead to a better understanding of our common past.

Keywords: Ivan Vitez, coat of arms, seals, illuminated codices, Slavonia, Hungarian Kingdom

Colour Stability of Verdigris Pigment on Paper Support

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Verdigris pigment was often used from antiquity until the 19th century and can be found in illuminations, book illustrations, and maps. It has been manufactured ever since antiquity according to many different recipes, from copper metal, vinegar (acetic acid), and other ingredients. Chemically, Verdigris is a copper acetate salt, either neutral or basic. It has often been mixed with other pigments, such as yellow saffron, to acquire more true green colours. Artists have been aware at least since the Middle Ages that Verdigris is prone to colour change. Usually it undergoes a natural colour change from blue to green in the first month after manufacture.

Furthermore, it can also cause severe degradation of paper and parchment support. Damage caused by copper corrosion manifests as colour changes in the painted areas, browning, embrittlement, and cracking of the paper or parchment.

The aim of the study was to detect colour changes on various paper samples with the application of Verdigris pigment during accelerated thermal degradation under relatively mild conditions (50 °C and 65% RH). Historically important neutral Verdigris paint films were applied on Whatman and handmade paper sheets. On some of the samples, two antioxidants, which are considered to be the most promising ones to stabilize copper corrosion, tetrabutylammonium bromide (TBAB) and benzotriazole (BTA), were also applied.

The results of spectrophotometric determination of colour expressed in CIE Lab* colour space show that untreated samples change from blue green to green during accelerated thermal degradation. Colour changes are more prominent after the application of BTA in comparison to TBAB treatment, rendering TBAB more applicable to prevent copper corrosion.

Keywords: Verdigris, paper, colour changes

Coloured paper and ink in Islamic manuscripts

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Coloured paper and coloured ink in Islamic manuscripts are still an under-researched topic. Basic information can be found in Adam Gacek's excellent codicological manual "Arabic Manuscripts: A Vademecum for Readers" from 2009. The little research on coloured paper in Islamic book culture is mostly concerned with luxury manuscripts. Such paper, however, is often found in modest manuscripts that were not intended for the elite strata of society.
We will present some examples of those manuscripts, but so far, we have not had sources that would help us answer the questions of whether they were made by order, whether the buyers considered such manuscripts more attractive than those made only of white or yellowish paper, and what aesthetic ideas were in the background of inserting just a few sheets of red, yellow or olive-green paper into a codex.
The basic ink used in Islamic manuscripts was black. Aside from it, red ink was used for different purposes. In this paper, the use of red ink will be analysed from three perspectives. Firstly, it will be determined which places in manuscripts red ink was used in. Secondly, we will try to answer the question of whether it was used by the author, the scribe, or the reader. Thirdly, and perhaps most importantly, we will examine the purpose which red ink is used for in manuscripts. Consequently, we will closely explore questions such as whether red ink makes it easier to understand the intentions of the people involved in the production and use of manuscripts.

Keywords: Islamic manuscripts, coloured paper, coloured ink

Temperature and relative humidity mapping in spaces containing moveable cultural heritage

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Exhibition, storage and transport of moveable cultural heritage is critically dependant on temperature and relative humidity conditions, especially in longer periods. Different materials (e.g. paper, textiles, wood, metal, paintings, photographs, bones, glass, ceramics) require different ideal conditions and it is not the best of practice to keep them in identical ones. For library materials specifically, in Croatia there is an Ordinance on protection of library materials (NN52/2005) and Ordinance on protection and keeping of archive and restoration materials outside archives (NN63/2004, NN106/2007). There is also a number of international guidelines such as IFLA Principles for the Care and Handling of Library Material.

Metrology, as an interdisciplinary and applied science, and technical metrology in particular, pays a lot of attention to methodologies for temperature and relative humidity measurement in controlled environments, so as to ensure effectiveness of various products and test results in laboratories. Among those methodologies, there are some that can be especially beneficial for spaces containing moveable cultural heritage, including those with library materials. Terminology used in the most beneficial international metrology documents includes wordings such as "calibration of temperature and/or humidity-controlled enclosures" or "temperature mapping of warehouses". It is important to stress that it is not about any changes in standard and well-established (or ordinance-demanded) temperature and relative humidity ideal conditions for cultural heritage, but about possible improvements in evaluating and checking those well-established values.

Based on the standard international guidelines from the field of technical metrology, the initial temperature and relative humidity mapping was performed in the Depository of Metropolitan library of Zagreb Archdiocese in order to show that there are significant advantages of such guidelines over traditional approach of measuring those parameters in spaces containing moveable cultural heritage.

Keywords: metrology, temperature, relative humidity

Inpainting or visual compensation methods on written heritage – case studies from the State Archives in Rijeka

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Inpainting is the addition of appropriate media to fills, repairs, and areas of loss in an artifact to restore visual integrity, create the illusion of wholeness, suggest the continuity of image and/or background and minimize the distraction of losses without compromising original intent or materials.
Different visual compensation methods are used in paper and book conservation, compensating losses of media, or/as well as support. Most written heritage objects, in particular archival documents held in our heritage institutions, are made of organic materials like paper, parchment, leather, wood, textile and similar materials, which means that inpainting often requires different techniques and materials for each of them.
Considering that archival records are almost always unique, rare, "one of a kind" objects containing first-hand legal evidence that must not be changed or compromised during conservation or restoration, inpainting of this particular type of written heritage must be done really cautiously, as aesthetic is generally considered less important than authenticity of an archival document.
Besides ethical considerations on inpainting of archival records, the aim of this presentation is to introduce common techniques, such as the use of dyes and paints, both for paper and animal skins, as well as less common methods, e.g. the use of thermically toned/aged cellulose fibres and digital printing.
Case studies from the State Archives in Rijeka include examples of visual compensation in areas of losses of media and support, stains, patterns, and material structures. This paper will discuss the advantages and disadvantages of each method.

Keywords: visual compensation methods, archival records, inpainting techniques

Cartography and Colours in the Croatian State Archives

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Maps have always been adorned with colours, which additionally clarified certain elements on maps. Colouring maps involved decorating and colouring accompanying illustrations, map borders as well as depicting political boundaries and other geographical elements, thus facilitating the reading of maps and understanding the content on them.
The aim of this paper is to present cartographic materials kept in the Croatian State Archives, with an emphasis on the Cartographic Collection and fonds the Archive of Maps for Croatia and Slavonia. The focus is on the use of colours on different types of maps between the 16th and the 19th century, specifically on the manuscript cadastral plans of the 19th century. To represent specific cartographic elements accurately, colour has been a crucial element in the creation of maps both in the past and today. Woodcut and copperplate maps were hand-coloured after printing, and, similarly, manuscript maps and cadastral plans were also coloured by hand. Colours, besides visually enriching the map, facilitate the understanding of cartographic symbols on maps and reveal some details that would not be as noticeable if they were not coloured. This paper will present thematic maps of various production techniques in relation to manuscript cadastral plans, where the use of colours is most prominently expressed.

Keywords: maps; cadastral plans; colours; Croatian State Archives

Painted incunabula in the Manuscripts and Old Books Collection of the National and University Library in Zagreb

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Painting in written heritage was most often researched in illuminated manuscripts, while incunabula were the subject of research from the printing aspect. Handmade decorations in incunabula have thus rarely been the research subject, partly because they are considered inferior to those in manuscripts. Croatian libraries store around two thousand incunabula, with diverse states of preservation/completion, provenance, and style, and some of them were hand-painted after printing. The type and scope of painted decorations vary from simple rubricating to complex historicized initials and independent miniatures. Monastery libraries preserved the majority of Croatian incunabula, which entered them contemporaneously with their creation and have been kept there to this day. The Metropolitan Library of the Archdiocese of Zagreb stands out for its richness and uniqueness but so do the Mala Braća Monastery and the Dominican Library in Dubrovnik. A rich collection of incunabula is stored in the National and University Library in Zagreb as well.

This research aims to determine and analyse handmade paintings and inscriptions in incunabula stored in the Manuscripts and Old Books Collection of the National and University Library in Zagreb.

The Collection is home to 204 incunabula, and their bibliographic information is available in the library catalogue. Among them are more than 70 copies with subsequently manually coloured text or images. For this research, complexity-wise, coloured ornaments are categorized into five groups. Colour, frequency and format of incunabula ornaments were analysed too. Results provide an insight into the type and scope of materials that make up a valuable part of our written heritage and will serve to create a preservation plan for its further protection.

Keywords: incunabula, painted ornaments, preservation

The Evolution of Printing Inks: From Ancient Formulations to Modern Innovations

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Printing inks have been evolving for centuries, from ancient rudimentary mixtures to the sophisticated formulations of today. Documented as far back as 2500 BC, ink has played a crucial role in shaping how we communicate, learn, and create. This paper explores the historical development of printing inks, focusing on their formulation and use before Gutenberg, during his era of the revolutionary printing press, and subsequent advances that led to the advent of specialized ink manufacturers. By examining chemical compositions, production methods and technological advancements, it highlights contrasts and continuities between historical and contemporary inks, providing insights into modern innovations that have shaped the future of printing. In the first half of the 19th century, the growth of literacy resulted in a demand for cheaper materials and more efficient production methods in printing, which had an impact on the quality of the craft. Traditional ink production methods, unchanged since the 15th century, were overshadowed by industrial advancements. Early inks, made from carbon-black and oil, were gradually replaced by formulations that prioritized cost and efficiency over quality. The manufacturing of printing inks transitioned from a craft to an industrial process, leading to the decline of traditional techniques. Historically, inks have evolved from the Chinese water-based formulations to Gutenberg's oil-based inks, with gradual improvements influenced by technological advances and industrial demands. The 19th century witnessed a shift towards chemically purified oils and synthetic additives, which were more efficient but often of compromised quality. From 1950 onwards, the printing ink industry evolved considerably due to the growth of the packaging industry and advancements in publishing technology. Ironically, despite this technological progress, recent efforts have focused on the development of water-based inks for environmental reasons, returning to a method used by inkmakers a thousand years ago. This overview provides a comprehensive insight into how the printing ink industry has evolved and adapted over time, balancing tradition and innovation to meet changing demands.

Keywords: Development of Printing Inks; Historical Ink Formulations; Modern Ink Innovations

From milky white to nearly chestnut brown paper

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Having inspected the condition of the preserved copies of Valvasor's Glory of the Duchy of Carniola, an extensive encyclopaedic work (bound in four volumes, folio format) of great importance for Slovenia and the western part of Croatia, carried out in the last few years, we found that the copies are mostly very well-preserved, including, surprisingly, the variety of colour in the text block paper, which ranges from milky white to almost chestnut brown.
In more than 30 copies of Valvasor's Slava found in Slovenian public, church and some other private libraries, four Croatian libraries (in Zagreb, Pula and Rijeka), and two libraries in Nuremberg, we established that the papers in individual copies of this books printed in Nuremberg in 1689 different substantially from each other. The difference is evident in watermarks, smoothness or roughness, fibrillation of cellulose fibres and colour. This diversity is in some cases visible within a single copy.
In this presentation we mainly focus on the range of colour or browning of the paper in the examined copies, which is sometimes a common occurrence even within a single volume.
We divides the examined copies into several groups according to the browning of the paper and then looked for parallels in the type of binding, frequent use, method of preservation of the individual copy and ownership or provenance.
In this paper we want to present the paper in text block in individual copies and provide possible explanation for such a situation.

Key words: paper, colour, printed book, 1689

Multi-analytical research on colour in written heritage - case studies at the Academy of fine arts in Zagreb

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Due to their value, uniqueness, and often great fragility, the research of old written heritage materials must be carried out carefully, using non-destructive and preferably non-invasive analytical methods. Paper or parchment substrate is often in very poor condition, and examining pigments and dyes may degrade, fade and thus further damage them.
In this paper we will present examples of the application of various analytical techniques for the investigation of colour on written materials during in-situ measurements and during measurements at the Scientific laboratory at the Academy of Fine Arts in Zagreb. This includes, for example, the analysis of The Trogir Evangelistary, The Linen Book of Zagreb, a study of the illuminated initial from the Missale Olomucense incunabulum etc. The principal methods used and discussed were X-ray fluorescence, Raman spectroscopy, fibre optics reflectance spectroscopy, and Fourier-transform infrared spectroscopy.

Keywords: pigments, XRF, non-destructive techniques

Colour & dignitas – the use of colours in the appointment to the banal dignity of Petar 4th Zrinski in 1665.

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There are very few charters by which monarchs appointed magnates to the banal dignity. The primary reason for this is that these charters were part of family archives, and they were frequently destroyed along with the other family archives. One of the unique charters of that kind is the one by which King Leopold 1st was appointed to the banal dignity of Petar 4th Zrinski in 1665, and by which he succeeded in the banal dignity of his brother Nikola 7th (who died a year before). The charter is composed in a codex comprising fifteen parchment pages (eight folios) in which the king's will of appointment is described. The charter is structured according to the rules of diplomacy from the early modern period. Therefore, parts of the charter stipulated by those rules are almost visually separated between themselves using various colours, ink, and types of letters. So far, this charter has not been thoroughly studied. This paper will present the results of the use of colour and ink. Results will be compared with the parts of the charter to confirm or negate their mutual connection.

Keywords: Diplomacy, Zrinski, colour, ink

Coloured print of the Diocesan Museum Archdiocese of Zagreb

Tomica Plukavec
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The Diocesan Museum (DM) of the Zagreb Archdiocese houses numerous graphics, which have not been sufficiently explored to date. The paper analyses, in a historical and cultural overview, the coloured graphics of DM, which was founded by cardinal Alojzije Stepinac in 1939. With its nine collections, the museum is considered one of the most valuable such institutions in Croatia. Among them is a collection of papers containing 1,655 etchings, 619 lithographs, 37 etchings and 90 drawings. The 19th century heralded a new era in the care for the preservation of cultural heritage. It then became clear that the cultural heritage was largely preserved within the framework of the Church. The need to preserve and present the cultural heritage of the Croatian church was particularly emphasized during the First Croatian Catholic Meeting held in Zagreb in September 1900. A new incentive for the preservation of church art came from the Holy See on December 1, 1925, in the form of a circular to all dioceses encouraging them to preserve church art. According to these instructions, the First Synod of the Zagreb Archdiocese, from 1925, defined in the VII. chapter of its conclusions a strong incentive for the preservation of sacred objects. The participants of the First Synod of the Zagreb Archdiocese were aware that many works of art had perished due to the remodelling and the renovation of churches. This also abolished the custom of burning dilapidated and damaged altars, statues, pictures and papers as well as consecrated objects on Great Saturday, allegedly, so as not to dishonour these consecrated objects. In order to bring to life the guidelines of the First Catholic Meeting in Zagreb, the initiative of the Holy See and the decisions of the First Synod, the Archbishop of Zagreb Alojzije Stepinac appointed a Commission for Church Art in 1935, with the task of establishing the DM in Zagreb. From today's perspective, it was an event of first-rate importance for that era in Croatia. A few years later, Bishop A. Stepinac opened the DM building itself. At that time, the Zagreb Archdiocese took the lead in protecting church's cultural heritage. Unfortunately, this situation lasted only until 1972, when DM was closed for public.

Keywords: Zagreb Archdiocese, Diocesan Museum, coloured graphics

Role and importance of microbiological and chemical testing conducted on books from the "Petar II Petrović Njegoš" library of the Njegoš Museum – Biljarda

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The "Petar II Petrović Njegoš" Library of is a mobile cultural asset of Montenegro, located within the museum unit of the Njegoš Museum-Biljarda, which is a part of the National Museum of Montenegro in Cetinje. The Library holds 374 library units (predominantly printed books from the 18th and the first half of the 19th century, along with several volumes of newspapers materials), one third of which bears "Njegoš's ex Libris", an authentic label, confirming that these specific units belonged to Petar II Petrović Njegoš.
This paper will provide an insight into the physical condition of the library and present previous chemical and microbiological examinations of the paper. The analysis of the state after the conducted test determined the measures for the protection and conservation of this collection. Microbiological and chemical tests were carried out in the laboratory of the National Library of Serbia in Belgrade on small samples of paper, using contemporary methods.
A detailed presentation of the procedures will also include the results obtained and demonstrate the significance of these analyses, which preceded the determination of the conservation measures applied to the books in this library.

Keywords: Library, Cetinje, Biljarda, ex Libris, printed books, protection

Illuminated manuscripts

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Illumination represents the art of decorating manuscript books and stands for drawn or painted miniatures, initials and various ornaments such as flags, decorative motifs on the margins, etc. Most manuscripts were preserved in the Middle Ages and today we can find them in public and university libraries, church libraries and museums, private collections and bookstores. Illuminator workshops in their beginnings were connected to monasteries, and it was not until the 13th century that they appeared at universities. In their beginnings, illuminations were enriched with plant and animal decoration, so miniatures depicting satire and grotesque and themes from everyday life characterized the Gothic period of the late Middle Ages (13th/14th century). Illustrated manuscripts were popular until the 15th century with the advent of printing. Until then, they were created in every part of Europe and in different conditions, from hermit cells in the mountains to printing shops in big cities. With their painted decorations, they have always attracted attention, even today, and among them we find some of the world's greatest artistic masterpieces. In addition to artistic masterpieces, other works of art such as manuscripts, binding and publishing have been preserved in them. Illuminated manuscripts are included in the category of "old and rare books" and this is why we consider them cultural heritage. Today medieval books are preserved in all parts of the world. The manuscripts are so different from each other that the provenance (ex libris, signatures, inscriptions, seals, etc.) allows us to follow their "life path", placing it in the context of place and time.

Keywords: illuminated manuscripts, cultural heritage, history

Blue Paper: History and composition

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European paper production started in the 13th century, and the first written reference to blue paper was in the Statute of the People of the Commune of Bologna in 1389. The document codifies format and quality standards for local paper producers. The high-quality 'royal' (*reali fini*), white paper of a standard size, was sold for five Bolognese libra ten soldi per ream and was therefore more expensive than the 'royal blue' (*reali azzurre*) by four libra per ream.

The composition of these two types of early papers is quite similar: They are made of hemp, linen, and cotton fibres that came from rags that also included blue-coloured fabric fragments. Blue-dyed fibres were combined with natural-coloured fibres to create the first blue sheets. Afterwards, the paper's blue hue was achieved by dying entire sheets of paper either by dipping them in dye or by dying the pulp of the paper before it was formed into a sheet. The origin of blue dye throughout history is of organic or inorganic origin, from vegetable dyes to pigments, so in the context of blue-dyed papers, woad, indigo, smalt and Prussian blue are mentioned.

Why the blue colour of paper and why did it remain until today? Compared to other coloured materials, blue paper has had far more commercial and artistic applications since its beginning. Two factors are mentioned by Irene Brückle: First, the attractive appearance; and second, it was the affordable cost, resulting from the financial benefit of processing blue fibre, that initially boosted the manufacture of blue paper in Europe.

Keywords: blue paper, woad, indigo, history, composition

Spectroscopic investigations of historical and modern blue papers

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Instrumental techniques such as scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and Fourier-transform infrared spectroscopy (FTIR) are increasingly used to investigate and identify historical papers. On the other hand, dyes and pigments are usually identified using Raman spectroscopy and X-ray fluorescence (XRF), especially since these techniques enable non-invasive testing. Still, most of the testing is done on illuminations, paintings and decorations, while the colour of paper itself is less intensely studied. Thus, the goal of our research is to attempt to identify the dyes or pigments used to colour blue paper used in binding, using light microscopy, SEM-EDS and FTIR, which we already successfully applied in studying samples of historic and modern paper.
As samples, booklets bound using blue paper, dating from the 19th and the 20th century, and published lecture notes dating between 1958 and 1963, were analysed, but also a modern blue envelope. Optical analysis using light microscope has helped identify whether the papers were coloured using blue-coloured rags or blue pigment while making the paper, or by applying the dye after the paper was made. FTIR spectra of paper were compared to reference spectra of blue dyes and pigments to verify their presence in the paper, which was difficult due to low intensity of these bands in comparison to those of cellulose. SEM-EDS mapping showed presence of mineral particles whose elemental composition could be identified and compared to those of known pigments.

Keywords: infrared spectroscopy, energy dispersive X-ray spectroscopy, electron microscopy, blue paper

The Colours of Written Heritage and Contemporary Papers

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The colour of paper had a significant impact throughout history, reflecting aesthetic, practical, technological, and cultural changes. In the Middle Ages, coloured papers were used in illuminated manuscripts for their aesthetic and symbolic value. Also, the use of coloured papers for the front sheet and book cover was not uncommon. During the renaissance, coloured papers were used for decorations such as wallpapers. The Industrial Revolution and mass production made various coloured papers widely available for writing, advertisements, and packaging. In the 20th century, the development of synthetic dyes and digital technology led to precise and rapid production of coloured papers. Today, coloured papers are utilized for a variety of purposes including packaging, printing, and decorative applications.
The aim of this paper is to investigate, through theoretical frameworks, the reasons and methods for colouring paper in written heritage and contemporary papers, and to examine optical and colorimetric properties using selected samples. To achieve this, methods for comprehensive characterization of optical and colorimetric properties of paper will be used. The significance of used measurements and multidisciplinary approach will be explained through the results of the tested samples. A conclusion based on test results and theoretical insights will be formulated to outline the distinguishing features of coloured paper in written heritage and modern, contemporary paper.

Keywords: paper colour, optical properties, colorimetric properties

The Hidden Blue of the Graduals from Badija

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The library of the Franciscan monastery of „Mala braća" in Dubrovnik houses both manuscripts and printed books. The printed collection comprises over 70,000 books, more than 1,000 of which originate from the 16th century. It also keeps 216 incunabula. The focus of our interest are two Graduals from the 14th century from the small island of Badija in the vicinity of the island of Korčula. A Gradual is a liturgical book containing a collection of sung parts of the mass. In the Catholic liturgy, it is a collection of antiphons, usually parts of psalms, which are sung after the first reading of the Mass; after the liturgical reform (1969) only the psalm remained. Our research focuses on the conservation and restoration studies of the handmade headbands of these books. In particular, we aim to prove that the headbands of the two Graduals were made with the same thread but on different cores. The first Gradual, "de sanctis" (Badija XII), has a headband on a cord core, while the second Gradual, "de tempore" (Badija IV), has a headband on leather core. This analysis includes a detailed examination of materials, manufacturing techniques and the state of preservation. In addition to analysing the components of the headbands, we will also conduct colorimetric measurements of the thread colour of the headband. This method will allow us to pinpoint differences or similarities in thread colour, which could provide additional evidence that the same thread was used in the two headbands.
The results of this research will lead to a better understanding of the techniques and materials used in the production of liturgical books in the 14th century. We expect that our findings will also open the door to further studies of similar liturgical books and other manuscripts from the same period and provide deeper insights into the material culture and art of medieval Croatia.

Keywords: Graduals, book headband, conservation-restoration research

Mechanical design of a 120-band hyperspectral imaging system

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One of the main and most important characteristics of any multispectral or hyperspectral system is the number of spectral bands it can record. A higher number of bands ensures a higher spectral resolution and a larger amount of data available for later processing. However, increasing the number of bands represents a problem and a challenge from the standpoint of mechanical design. A higher number of bands means a larger number of spectral filters, which also means a larger and more complex positioning system.
A significant increase in the number of filters turns the system from a multispectral to a hyperspectral one. When designing and building a system with over 100 bands, mechanical challenges become exceptional, especially when larger filters are used.
This paper will present the design and development of a mechanical system capable of positioning 120 spectral filters, while maintaining a compact and simple mechanical design. The system is scalable and capable of positioning an arbitrary number of spectral filters. An additional unique challenge with our system is the use of three sets of different cameras and lenses used to extend the imaging spectral range to 350 to 1700 nm. In other words, the system must simultaneously position and pair individual cameras with appropriate spectral filters. The positioning of both systems was achieved using two rotational and one linear motion system. The main components of the system were made using additive manufacturing, which ensures quick and easy modification of the system if the number of filter changes. The entire system was powered by off-the-shelf stepper motors and electronics, while motion was managed by an Arduino microcontroller. Custom microcontroller software was developed that automatically matches cameras with appropriate spectral filter based on the spectral band requested by the user. The developed system represents the main building block of our hyperspectral imaging system.

Keywords: hyperspectral, camera, additive manufacturing

Hyperspectral camera as a spectrometer in the preservation of written and printed historical materials

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Hyperspectral imaging systems are transforming the preservation of historical artifacts by facilitating a detailed analysis and precise identification of materials used in artifacts. This paper explores various aspects of using a hyperspectral camera as a non-contact spectrometer in the analysis and preservation of cultural artifacts. These spectral imaging systems use the Kubelka-Munk theory of reflectance to identify pigments, providing insights into the composition of materials present and the condition of historical documents and artworks. Spectral imaging reveals hidden information, such as invisible layers in paintings and manuscripts.
In the preservation of artworks, spectral cameras assist in the restoration of damaged parts by detecting original pigments. In the context of art conservation, hyperspectral cameras provide tools for repairing damages and monitoring conservation work and the condition of artworks. One of the key advantages of spectral cameras is their ability to analyse the spectrum of each pixel in an image, allowing for precise identification of materials and their distribution across the entire surface. This capability enables the identification of hidden damages and precise restoration.

Keywords: Hyperspectral camera, spectral imaging, pigment identification

Analysis of the spectrum of illuminations in books from the 14th and 15th centuries obtained with a hyperspectral camera

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This article presents the application of hyperspectral camera in the analysis of illuminations from books dating from the 14th and 15th centuries. Hyperspectral imaging allows the identification of various pigments and materials used in artworks. Spectral cameras analyze the reflectance of light from the surface of objects, providing insights into their composition and structure. The application of this technology in art preservation helps uncover hidden layers and details invisible to the naked eye.

Throughout history, different pigments have been used depending on the availability and technological capabilities of the era. The main challenge in pigment analysis is separating the measured reflectance to identify the different components. Linear separation does not work because the mixing of materials is not linear, materials can mix almost at the atomic level. The application of hyperspectral cameras in the analysis of illuminations from books from the 14th and 15th centuries brings invaluable benefits. These technologies enable in-depth analysis of color layers and underlying sketches, revealing the techniques and materials used in creating these works. Hyperspectral cameras allow for precise identification of pigments and materials, which is crucial for restoration and conservation.

Keywords: Hyperspectral imaging, spectrum interpretation, illuminations

Recipes for illuminating and writing manuscripts recorded in the technological manual Secrets of Colours (Segreti per colori)

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In November 2016, a book entitled "Secrets of Colours" (Croatian: *Tajne o bojama*) was published by the Croatian Conservation Institute. It is a translation of the technological manual *Segreti per colori*, written in the 15th century. Ever since it was found in the library of the monastery of the Holy Savior in Bologna, it has been known as the "Bolognese manuscript". It is a large collection of 392 recipes that cover a very wide area: from making pigments and dyes, to dyeing parchment, making artificial gems and mosaic paste to enamels, dyeing leather, thread and canvas.

The manuscript is divided into several chapters, but the recipes are not systematically classified to the end, and recipes with similar content are often found in different places in the text.

Should the reader pay attention to the binders mentioned in the manual, they will notice that by far the most frequently mentioned are gum arabic and egg white, which are the standard illuminator binders. It can thus be assumed that the author of "Secrets of Colours" was mainly addressing people who painted manuscripts and very rarely painters of easel paintings, because classic binders of that painting, egg yolk and later oil, are rarely mentioned.

We focused our attention on recipes where the connection with illumination of parchment or scribal work is explicitly stated. These are recipes which directly state a book (*libro*) or a *carta* as the object of activity, in the case of *carta* referring to parchment and not paper. We also examined recipes which feature the expressions to write (*scrivare*, *opperare a penna*), *illuminate* (*miniare*), *illuminations* (*minii*), *letters* (litera) appear. Furthermore, we concentrated on recipes mentioning *scisa*, a base for gilding manuscripts, as well as recipes that mention rags (*peze*) soaked in dyes, which were used in painting manuscripts, or the ink (*inchiostro*), used to write manuscripts in.

All of them contributed to obtaining a clearer picture of how illuminated manuscripts were created and what the role of colours in that process was.

Keywords: Secrets of Colours, Bolognese manuscript, illuminating



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