

MAGAZINE FOR EXPERTS IN ART RESTORATION
AND ANALYSIS OF IRREPLACEABLE ORIGINALS

reSOLUTION

Restoring Former Glory with Cotton Buds and a Microscope

The Princely Collections of Liechtenstein

Ancient Feast of Colour

Danish Scientists Research Colour in Antique Sculptures

Save our Memory

A Look Inside the Restoration of Historic Photos

SPECIAL EDITION



Dear Readers,

You have before you a special issue of our reSOLUTION customer magazine for Materials Science & Technology, dedicated to the colourful world of art restoration and cultural heritage.

For experts who occupy themselves with examining and conserving artistic, cultural or natural history artifacts, precise viewing is the most important requirement for successful work. Tiny residue of colour pigments on ancient statues, saponification in paint layers of old paintings, tool marks and damage on antique furniture, tiny inclusions in minerals or the paper structure of historic photographs provide information about the age, origin and history of an object. In particular, non-contact and thus non-destructive methods such as light microscopy play an important role when working on these irreplaceable originals. However, the precision of a microscope is also often indispensable for restoring, conserving, documenting and analysing specimens of different materials.

Leica Microsystems supports the work of conservators, archaeologists and experts in related fields with a wide variety of products and individualised solutions. For example, with the new Leica F12 I floor stand: It is specially designed for the needs of conservators and for working on large objects in vertical or horizontal position.

In this issue, read about research on the colours of ancient sculptures and the conservation of old photographs. Enjoy the wonderful photos of mineral inclusions in gemstones. Gain an insight into the restoration workshops of important collections.

Have fun reading!

Anja Schué
Communications & Corporate Identity

Carola Troll
European Marketing Manager Industry

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The Princely Collections of Liechtenstein

Restoring Former Glory with Cotton Buds and a Microscope

Anja Schué, Leica Microsystems

On her way to work, Ruth Klebel is often approached by tourists asking for the times of guided tours. She always gives the same answer before disappearing behind the wide automatic gate: “I’m afraid there aren’t any, this is private property.” As a restorer of the collections of the Prince of Liechtenstein, Klebel is one of the very few people who regularly come and go at Vaduz Castle without actually living here. Standing in solitary splendour on a rock terrace high above the capital of the principality of Liechtenstein, the castle is the home of one of Europe’s oldest aristocratic families.

A bearer of this name, Hugo von Liechtenstein was first mentioned around 1136. The beginnings of the Princely Collections date back to the time of the family’s rise to principedom in the 16th and 17th centuries – a time of intensive patronage of the arts by the European aristocracy.

At home in Vaduz – exhibited in Vienna

Since the restoration of Vaduz Castle in 1938 and the move of the Princely Family to Vaduz, this is the home of the collections, too. However, only a few of the art treasures are open to the public, and most of these are housed in the LIECHTENSTEIN MUSEUM in Vienna – the city that has played a key role in the life of the family for many generations. Temporary exhibitions in the LIECHTENSTEIN MUSEUM in Vaduz give further insights into the diversity of the collection.

Today, the Princely Collections rank among the most important private art collections worldwide, and the Princely Family still takes an active part in adding to them. They mostly comprise works from the period between the 15th and 19th centuries, with a focus on early 17th century Baroque paintings. Besides bronze sculptures and decorative arts, they also include a notable Biedermeier collection, which is to be exhibited in Vienna’s Stadtpalais in a few years’ time. At present, the building is still undergoing renovation. Klebel, who also has her own studio in Bregenz as well as working as a member of the restoration team for the Princely Collections in Vaduz, mainly looks after the



Fig.1: Ruth Klebel works as a restorer for the art collections of the Prince of Liechtenstein.



Fig. 2: Willem van Honthorst (1594-1666) "Portrait of a Young Man Holding a Plumed Hat in his Right Hand". The almost life-size portrait dating from the first half of the 17th century requires extensive restoration. ©Sammlungen des Fürsten von und zu Liechtenstein, Vaduz-Wien

paintings. Her job involves conservation, restoration, supervising storage conditions, and drafting loan and transport evaluations.

Ms Klebel, what are you working on at the moment?

My present task is a work of the Dutch painter Willem van Honthorst from the first half of the 17th century. It shows the almost life-size portrait of a young man with a plumed hat. The canvas of this painting has to be repaired as the edges have been damaged by excessive tension. The surface of the painting will also be treated, areas of earlier repainting will be removed and the degraded varnish will be reduced with appropriate solvents.

The surface of the portrait is unusually rough. Looking through the stereomicroscope, I noticed that the roughness is caused by grains/impurities in the varnish. This layer was definitely applied at a later date than the execution of the painting. Restoring old paintings is often not only a matter of repairing damage to the original substance. Most paintings have already been reworked or restored in the past, and not all efforts have had a positive influence on the original substance.

Art restoration did not become a profession in its own right until the 19th century. Before this, restoration work was frequently done by painters, who overpainted missing areas or even whole sections of the picture. If possible and advisable, we remove these layers, as our aim is to restore the original intention of the artist in relation to the age of the artwork.

What do you use the microscope for?

For one thing, the microscope is used to examine works of art. I take an exact look at the paint layers, as well as the support which can be from canvas, wood, metal, glass etc..., to localise and identify the source of specific types of damage. The state of preservation of the painting is also documented with various types of photographs using different light sources.

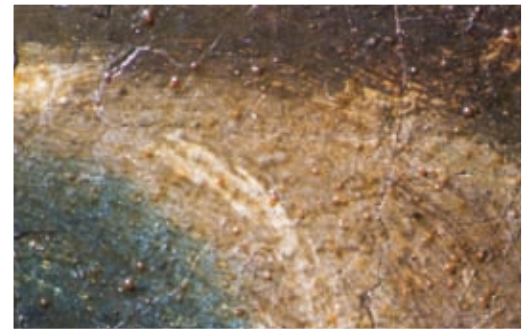


Fig. 3: The microscope examination shows the rough granular surface of this Dutch painting which is a result of a later application of varnish with poorly dissolved components. ©Sammlungen des Fürsten von und zu Liechtenstein, Vaduz-Wien

For sophisticated conservation and restoration work, such as stabilising loose paint layers or removing layers of non-original material, the microscope is indispensable. I use a stereomicroscope with floor stand, which offers the flexibility and reach I need for working on large objects. Both for working on the painting itself and for the photographic documentation, it's essential that the microscope/stand combination is highly stable and as vibration-free as possible.

How do you use the microscope for the repair of the canvas?

The microscope is in vital for repairing tears and holes in the canvas, too. The torn ends of the threads are rejoined with one single spot of adhesive. The pattern of the weave is imitated and it is ensured that the tension of the glued threads is the same as that of the intact fabric, as otherwise bulges or indentations appear in the repaired area. This procedure can be tremendously time-consuming.

An example of canvas repair is a still life of flowers by the Dutch painter Rachel Ruysch dating from about 1700. The microscope was crucial for this restoration process. The painting was relined, that means a second canvas had been adhered to the reverse of the original canvas support to help stabilise it. It was decided to remove this second canvas, which subsequently left most of the old adhesive attached

to the reverse of the original support. This residue was removed under the stereomicroscope with a highly tuned air abrasive device. The original canvas also had many losses due to insect infestation which penetrated to the paint layer. The missing threads in these areas were replaced by new ones which were glued to the ends of the original threads.

How important are illumination and ergonomics?

The illumination plays a very important role. It has to be variable and precisely adjustable, and the arm must not get in the way. We often have to move the light quite close up to the surface of the painting. To resolve extremely fine changes to the surface and raised structures, we need raking light – having the surface illuminated at an extreme angle from the side, usually from the left. Flexible illumination is critical for photography, as well. I spend a lot of time with the microscope – some days with five- to six-hour sessions. The work requires absolute concentration, so ergonomics is a serious issue for me. I make sure I sit in a comfortable position and I find features such as tube with an adjustable viewing angle of 0 – 180° very helpful in making spells at the microscope less tiring.

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Fig. 4: Rachel Ruysch (1664-1750), "Flowers in a Vase", ca. 1700. Here, the severely damaged canvas was restored, the degraded varnish reduced, non-original layers removed and damaged paint layers retouched. ©Sammlungen des Fürsten von und zu Liechtenstein, Vaduz-Wien



Fig. 5: To repair tears in the original canvas, threads are individually inserted and adhered to the intact fabric under the microscope. ©Sammlungen des Fürsten von und zu Liechtenstein, Vaduz-Wien



Fig. 6: After uncovering the original paint layer of the still life, details of a campanula become visible under the microscope. ©Sammlungen des Fürsten von und zu Liechtenstein, Vaduz-Wien

Revealing the Secrets of a 17th Century Masterpiece

Restoration in an Open Workshop

Anne Haack Christensen, Troels Filtenborg, Dr. Jørgen Wadum, et al., Statens Museum for Kunst, Copenhagen

For more than a year from August 2007 through October 2008 museum visitors of the Statens Museum for Kunst, the Danish National Gallery in Copenhagen, were able to experience an open conservation studio in the exhibition area. The reason for bringing the conservators and all their equipment into the exhibition rooms of the museum was the conservation, restoration and technical research of Jacob Jordaens' (1593 – 1678) early masterpiece "The Tribute Money. Peter Finding the Silver Coin in the Mouth of the Fish", also known as "The Ferry Boat to Antwerp". The process of restoring the painting and investigating the painting technique, materials, history of conservation and provenance of the artwork turned out to reveal unexpected and so far unknown aspects about the genesis of this large masterwork, painted in oil on a canvas measuring 280 x 467 cm.



Fig. 1: The microscopic work in the open workshop in the museum gallery



Fig. 2: X-radiograph (detail) with the revealed head of a woman painted over.

Technical investigations reveal hidden figure

Throughout the project, the painting was extensively examined through a number of different analytical methods. With a stereomicroscope, partly donated by Leica Microsystems, x-radiography, Infrared Imaging (IR), Scanning Electron Microscopy (SEM-EDX), Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography Mass Spectrometry (GCMS) conservators and conservation scientists have investigated and analysed the paint surface, paint- and ground layers, pigment particles, composition, binding media and canvas support. The project was supported with a Getty Conservation Grant from the Getty Foundation and was closely followed by an international advisory body of experts within conservation, art history and the natural sciences.

The digital x-radiograph generated an entirely new realisation of how the masterpiece originally evolved: hidden below a cloud in the sky between the sail and the men to the right of the disciple Peter are the complete features of a painted woman. The woman belongs to a motif very similar to the painting we see today and is part of a completed but less extended version of “The Ferry Boat to Antwerp” initially carried out by Jordaens. He must then have changed his mind and expanded the painting in four successive stages. While originally commenced on a much smaller scale on two pieces of canvas sewed

together, our painting is composed of eight pieces of canvas of varying size and quality.

Disseminating knowledge to museum visitors through a microscope

The museum decided on the open workshop because, as a National Gallery, it feels an obligation to explain to the public how our cultural heritage is researched and cared for. Another goal was to present all aspects of the conservator’s job – from investigating and preserving the artworks to developing ideas for using cultural resources. During the open workshop visitors were able to follow the work of the conservators live on a 50” plasma screen connected to the stereomicroscope. This allowed the visitors to experience the complexity of the paint surface as closely as the conservators.

Although the restoration is now completed and followed by a focus exhibition “Jordaens. The Making of a Masterpiece” a description of the treatment processes, analytical methods and results are still available on the website of the Statens Museum for Kunst:

www.smk.dk/jordaens



Fig. 3: Saponifications in the paint surface visible as tiny white spots penetrating the paint layers

Paint surface phenomena identified

The stereomicroscope, a Leica M651 equipped with a 150 mm objective for large working distances and a floor stand with a flexible swivel arm for horizontal and vertical manoeuvrability was used for the examination and analysis of the paint surface before, during and after the restoration process.

When cleaning the aged and yellowed varnish layers – across some fourteen square metres – as well as the discoloured retouches, the stereomicroscope was used extensively in order to continuously distinguish between original paint and later alterations. Numerous areas of blanched paint and varnish marred the appearance of the painting extensively, many of the faded retouches being evidence of earlier conservators' work. Blanched areas, both in the varnish and in some areas of the paint, further added to the hazy and dull appearance of the composition's details. After the cleaning, extensive retouching was needed to close lacunae and adjust transparent or abraded areas in order to give this majestic and spectacular painting the presentation it deserves.

The utility of the microscope was also applied in localising phenomena such as saponifications protruding through the surface of the painting caused by molecular changes in the lead white pigments of the ground layers. This phenomenon reveals itself in lead soap formations developing in the ground

layers eventually forcing the growing formations to penetrate the paint, appearing on the surface of the painting as small whitish dots 100 µm across.

A puzzle of canvas pieces and grounds

An in-depth study of the various ground layers applied during the four stages of the painting process was carried out analysing and photographing a number of cross-sections with a Leica Research Microscope DM 4000 M equipped with a Leica Digital FireWire Color Camera System DFC490. This was done to gain insight into the structure and composition of the grounds on all eight pieces of canvas and thus more comprehensively understand the complex development of the painting. Samples from the eight canvas sections have shown that the composition of the grounds differs between the four stages of the painting process, confirming the sequence of Jordaens' enlargement of the painting.

The research on Jordaens' priming technique and the complexity of the ground layers in "The Ferry Boat to Antwerp" will be described in detail by Bredal, Filtenborg, Verhave and Wadum in the article "Determining trends and Developments in Jordaens' priming techniques" to be published in 2010 in the book "Jacob Jordaens, a painter of great distinction: current research on his oeuvre" – a new volume in the series of Cultural and Interdisciplinary Studies in Art (ed. Muench & Pataki) Stuttgart, ibidem-Verlag.

Questions answered and raised

The art historical research has focused on the painting's provenance in the context of the modes of thought and values of the time. The painting is also a deposit of the society of the 17th century, defined by conventions of its time that were influenced by economy, religion, culture and politics, as well as the relationship between artist and client. The research has outlined the journey of the painting from Jordaens' Antwerp studio to a major house in Amsterdam's centre, to a remote Swedish manor house before reaching its final destination in Copenhagen in the early 20th century. The relation between Jordaens' enlargements of the painting in four stages and the original intention of its hanging is still not fully understood.

The project has provided new insight into Jordaens' artistic and technical development and the origin of the 400-year-old painting. The in-depth study of the painting's provenance, painting technique and conservation history has answered many questions, while new ones have been raised throughout the project. The puzzle with the eight pieces of canvas was resolved as a result of the extensive technical analysis of the painting including the thorough research on the ground layers as well as a Carbon 14 dating of one of the canvas pieces, but there are still questions to be answered about exactly how the painting evolved and why Jordaens made the changes that he did.

The restoration was accompanied by a large and fully illustrated book which goes even deeper under the surface and lays out the various approaches and results of the most recent research, giving a thorough picture of Jordaens, his works and his time. Articles by: Troels Filtenborg, Lars Hendrikman, Badeloch Noldus, Karsten Ohrt, Eva de la Fuente Pedersen, Annefloor Schlotter, Johanneke H. Verhave, and Jørgen Wadum. "Jordaens. The Making of a Masterpiece", 120 pages, ISBN 978-87-92023-26-1.

The book was made possible thanks to the support of The Getty Foundation and was published in collaboration with the Bonnefantenmuseum, where a comparable yet expanded focus exhibition was staged early in 2009.

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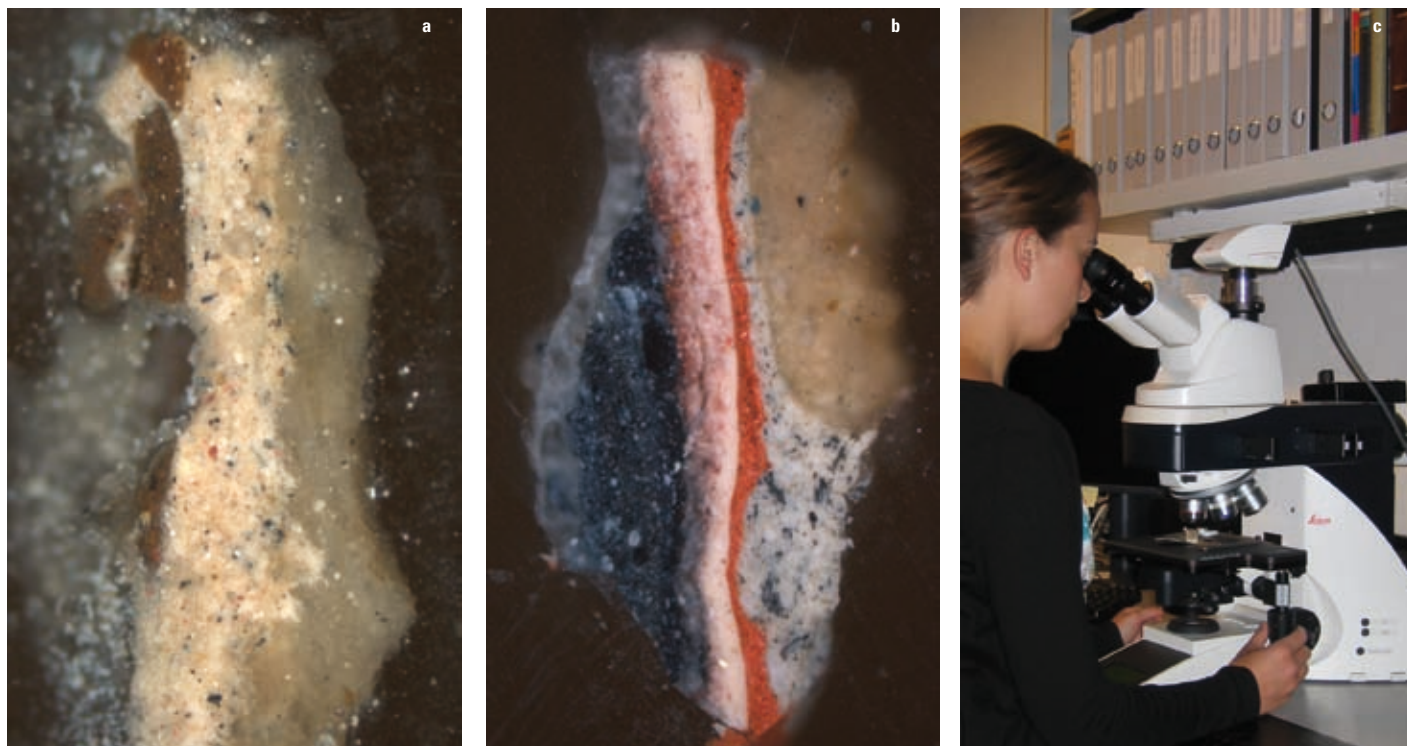


Fig. 4a – c: Two cross-sections from "The Ferry Boat to Antwerp" (magnification 100x) photographed with a Research Microscope Leica DM4000 M with a Leica DFC490 camera (c). 4a shows a cross-section from stage 1 in the painting process (belonging to the painting section with the now hidden woman), while 4b is a cross-section from stage 3 in the painting process. The samples clearly show the discrepancy in pigment composition in the two double grounds.

Danish Scientists Research Colour in Antique Sculptures

Ancient Feast of Colour

Kerstin Pingel, Leica Microsystems

Everyone knows that antique marble sculptures were white. Or were they? Scientists of the Copenhagen Polychromy Network (CPN) help to show that the statues of the Greeks and Romans were decorated with extravagant ornaments and sumptuous colours. With the help of the Leica M651 surgical microscope, the conservators detect tiny traces of paint pigment that suggest a veritable feast of colour in ancient times.

"True beauty is white" maintained, for example, the great German 18th century scholar Johann Joachim Winckelmann. This statement still dictates our viewing habits today. And yet it has been known ever since the 19th century that antique sculptures were polychrome, "many-coloured". Minerals like blue azurite or green malachite were finely ground and mixed with binding agents such as egg or casein. The polychromy of the sculptures enhanced their three-dimensional impression and gave the viewer important clues on understanding the work of art. For instance, visitors to the Acropolis in ancient times could only recognise the figure of the "Persian horseman" as coming from the Orient by the typical diamond-shaped pattern on the trousers.

Interdisciplinary network for basic research

The touring exhibition "Bunte Götter" (Gods in Colour) shown first in the Munich Glyptotek in 2003 and then in Copenhagen, Rome and many other cities has meanwhile acquainted a large number of museum visitors with reconstructions of the polychromy of antique sculptures. "We know that colour was an integral part of all Greek and Roman sculptures," says Jan Stubbe Østergaard, Research Curator of ancient art in the Ny Carlsberg Glyptotek, Copenhagen. "But we are far from really understanding this phenomenon." Of the thousands of antique sculptures in museums all over the world, only relatively few have been studied in-depth with regard to their polychromy. The aim of the Copenhagen Polychromy Network, an interdisciplinary research team consisting of the Ny Carlsberg Glyptotek, the School

Fig. 1: Sumptuous colours give life to this reconstruction of a lion statue. Reconstruction by V. Brinkmann and U. Koch-Brinkmann
Photo: Ny Carlsberg Glyptotek





Fig. 2: With the help of a surgical microscope, conservator Maria Louise Sargent documents traces of colour on a Greek marble portrait dating from the late Hellenistic period around 100 BC. Photo: Ny Carlsberg Glyptotek



Fig. 3: Surgical microscope image of the right eye of the Greek portrait. Eyelashes and other painted details are clearly visible. Photo: Ny Carlsberg Glyptotek



Fig. 4: Surgical microscope image of the minute traces of a blue pigment on the sphinx. It is as yet unidentified. Photo: Ny Carlsberg Glyptotek

of Conservation of the Royal Danish Academy of Fine Arts, the Geological Museum of Copenhagen University and the Institute of Chemistry of the Technical University of Denmark, is therefore to conduct research on sculptures in the Glyptotek and document traces of colour. The matter is urgent because such traces are gradually disappearing.

Spectators welcome!

One of the scientists' main tools is the Leica M651 surgical microscope. It stands in a glass-walled workspace in the galleries where the images are directly transmitted to a screen by the integrated video

camera. Here, visitors can look over the shoulder, as it were, of conservator Maria Louise Sargent.

Microscope images the only evidence

The first "patient" to be examined by Sargent with the Leica M651 is a Greek limestone sphinx figure made around the year 580 BC. Some of the remains of paint on this sculpture are visible to the naked eye, others so minimal that samples cannot be taken. "The only evidence of colour is what I see through the microscope," explains the conservator. "So it's vital that I examine the sculpture systematically to enable the pigment traces to be found again at any time. Leica's

surgical microscope is ideal for my work as it is easy to move and I can assess the works of art comfortably from all sides."

Cooperation with British Museum

In her search for traces, Sargent found infinitesimal remnants of blue paint. For the identification of the pigment, the Danes are setting their hopes on their coming collaboration with the British Museum. The "giant" of Europe's museum landscape has started a polychromy project on the model of the CPN and works together with the CPN as external research partner. "Our colleagues at the British Museum have developed a non-invasive method of detecting Egyptian Blue using UV photography. We're hoping this will give us more information," says Østergaard optimistically.

Traces of 2000 years revealed

The next candidate waiting for Maria Louise Sargent in the work space is a Greek marble portrait dating from the late Hellenistic period around 100 BC. It is the first time that a Greek portrait of that period has

been examined so systematically and with the microscope. "The works of art are over 2000 years old, and they have quite a story to tell," says Sargent. "That is to say, I can see a lot of traces, including traces of pollution or aggressive cleaning agents. The difficult part is to identify the traces correctly." After all, the ancient painters used materials like red ochre as a colorant, which is an earth colour. So what is paint, and what is just earth from the find spot? Charcoal was used for the colour black, but modern air pollution is indicated by carbon particles, too.

A controversial point: Was skin coloured or not?

Just looking at the Greek portrait currently under examination with the naked eye, we can see various traces of colour in the pupils, on the eyelashes and the lips. Østergaard is hoping for really important discoveries: "The examination of this object may help to solve the problem of whether skin on ancient sculptures was painted or not. To date, we have only one single proof from the Classic and Hellenistic periods that a body was painted skin-coloured."



Fig. 5: A portrait of Caligula, roman emperor from 37 – 41 AD, is one of the first examples for reconstructing the polychrome version of Roman sculptures. Photo: Ny Carlsberg Glyptotek



Fig. 6: How did the antique Caligula look like? This reconstruction by V. Brinkmann, U. Koch-Brinkmann and J.S. Østergaard.

Physical analysis reveals origin of paint

If enough paint is found, tiny pigment samples are taken and examined in cross-section under the Leica DM2500 materials testing microscope to determine layer structure and if possible identify pigments. Some are subjected to physical analysis by CPN partner institutions. It was thus possible for Minik Rosing of the Geological Museum to pin-point the origin of a pigment by an analysis of the isotopic trace elements: "The red lead oxide of one sculpture came from Spain and was exported to Rome," says Østergaard. "This tells us something about ancient trade routes as well."

Still a lot to do in polychromy research

Although the "Gods in Colour" exhibition has reached a wide public with spectacular, research based reproductions, polychromy research is still in its early stages. "Even though we can identify colours on antique sculptures, we don't know what they really looked like," says Østergaard. "We need to know more about the refined details of technique and about the aesthetic effects of the ancient polychrome works of art." The new discoveries made examining the

many sculptures of the Ny Carlsberg Glyptotek with the Leica M651 will be shown in a large exhibition in Copenhagen in 2012.

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tion was made for the first exhibition of "Bunte Götter" in 2003.
stergaard. Photo: Ny Carlsberg Glyptotek

Fig. 7: A later reconstruction of Caligula, based on the same research and done by the same team, is more hypothetical in its higher degree of naturalism. Reconstruction by V. Brinkmann, U. Koch-Brinkmann and J.S. Østergaard. Photo: Stiftung Archäologie, München

A Look Inside the Restoration of Historic Photos

Save Our Memory

Sam Habibi Minelli, Alinari 24 ORE

In 1852 Leopoldo Alinari, with his brothers Giuseppe and Romualdo, founded a photographic workshop in Florence, which is at the heart of the firm that still bears his name: Fratelli Alinari. It was the beginning of a unique endeavour that specialised in photographic portraiture, works of art and historical monuments, achieving national and international recognition. With the help of stereomicroscopy technology from Leica Microsystems Alinari is able to preserve the cultural heritage – our memory – for the future generations of professional restorers.

century building known as 'delle Leopoldine'. The importance of this museum is also illustrated by its collection of cameras, advertisements, paper documents, frames and all those objects connected to the photograph which can be considered an integral part of its history. Another 'vital' sector of the museum is the library specialising in the history of photography, with over 20,000 books and journals. The various exhibitions and projects focus on the educational aspect making the collections accessible to a heterogeneous public. One of the primary aims of the MNAF is to create a network of scientific and artistic institutions on a regional, national and international level.

Photographic restoration laboratory

Our restoration laboratory pursues conservation treatment and restoration from the great public archives deposited in museums, libraries, institutes and academies to materials belonging to the archives of industries and firms as well as private individuals. The laboratory is available for consultation and advisory services and various types of conservation treatment.

The Alinari laboratory engages in conservation treatment of many types of materials from the oldest daguerreotypes to calotypes, photographic prints, rare negatives on paper, collodion and silver glass-plate, up to the most recent colour proofs and negatives. We use the latest generation of Leica Microsystems' stereomicroscopes, Leica M205 C with FusionOptics™, video and 3D analysis for acquiring, storing, annotating and displaying high quality images of our heritage which needs restoration. Thanks to the fact that the microscope has an integrated digital camera, we can work using a large high definition flat screen instead of looking through the binocular tube of the microscope, thus allowing team collaboration.

The name of Alinari guarantees more than 150 years of experience and state of the art professional technology. Today there are over 2,750,000 b/w and colour negatives in various collections, from plates to colour photos, and over 900,000 vintage prints, including salted paper, albumen, bromide prints, calotype negatives, daguerreotypes, etc., preserved in the collection of 6,000 original albums. These are works by the greatest nineteenth and twentieth century photographers, both Italian and non-Italian, but also by many other less-known professional and amateur photographers. In 2001 the digital archive was inaugurated that continues to grow with images that can be viewed online. Today there are over 450,000 pictures available on the web (www.alinari.it).

Alinari museum and library

The collection of the Fratelli Alinari Museum of the History of Photography was established in 1985 and completed with a gallery in 1997 in Palazzo Rucellai on Via della Vigna Nuova and now in Santa Maria Novella. The Alinari National Museum of Photography (MNAF) is currently located in the fifteenth-

Fig. 1: The 150 years of Alinari's activity were celebrated with a special national stamp.



Photos: Alinari Archives

In collaboration with the state institute for art restoration in Florence and the Italian Ministry of Culture, Alinari holds nine professional courses dedicated to the restoration of photographic materials. The target audience are professional restorers, archivists, historians and researchers who already have a good background in these topics. The courses include theoretical and practical experiments using the Leica M205 C. The microscopic analysis supports the recognition of the original material, the analysis of the conservation status and effects of different methods of restoration.

The courses run by Alinari in collaboration with companies, universities and institutions offer a unique opportunity for teaching and providing continuous upgrades of knowledge to professionals on how to preserve the cultural heritage: photographic degradation is an intrinsic process due to the nature of photography. In fact, it is generated by a chemical and physical alteration of the light on the photo-sensitive substances.

The restorer and conservation managers aim at slowing down this process, where possible, by operating on the micro-ambiance (conservation cases and boxes) and on the macro-ambiance (archive rooms and thermo-hydrometrical parameter management: humidity, lighting, quality of the air, temperature, etc.). After appropriate analysis and the recognition of the photographic process, the restorer can execute direct restoration of the photography.

Our professional courses take advantage of the digital management of the microscope: we project the microscope view through the control panel of the microscope, we provide live micro-navigation and 3D views of the degradations. The researcher and the restorer can annotate the pictures using a wide range of tools for measurement and reporting. Video sequences are executed to see and evaluate how some chemical agents react on the paper or on other photographic surfaces. With the multi-point focus we obtain images which could not be realised until now: better quality and more information on the object under analysis.

Alinari is going to set up a lot of new research projects to respond to the needs and scenarios provided by the restoration laboratory while using microscope techniques.

Externally offered services

Alinari offers access to its collection and laboratory for external researchers and companies for collaborative research activities, general knowledge and expertise. Our services are also offered to government bodies for analysis and reporting about photography authentication, courses/workshops and publications for safeguarding photographic collec-

tions, such as ANAI (Associazione Nazionale Archivistica Italiana), and the Ministry for Cultural Heritage and Activities.

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Stereomicroscopy in photo restoration at Alinari's

- Recognition of the photography (daguerreotype, albumin, etc.)
- Diagnostics of the preservation status (the restorer detects, analyses and reports through a protocol form about all possible physical and chemical degradations: scratches, abrasions, craquelures, fading, mould, etc.)
- Verifying the restoration workflow
- Monitoring the preservation status
- Restoration and preservation of the originals
- Analysis of the original supports (glass, paper, daguerreotype, collotype, etc.)
- Training for internal and external experts: cataloguers, museum management
- Reporting of biological/physical/chemical alteration of the picture and its support
- Implementation of a data structure for monitoring large collections
- Collecting data and populating a Ground Truth as input to R&D
- Release of guidebooks, reference tables and chart flows

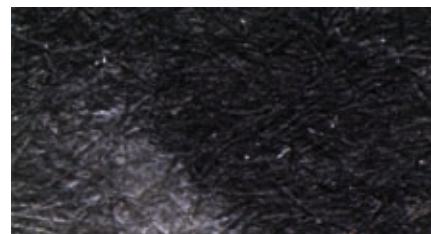
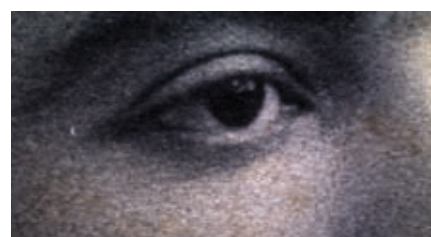


Fig. 2: Restoration laboratory using microscopy techniques.

Voices of Alinari's customers

Dr. Hans Petschar, Director Picture Archives Austrian National Library, Vienna: "It is amazing to see how the work of the restorer can be improved by this technology: you can analyse, document, report and reduce the effort whilst improving the quality of the results."

Roger Bruce, Director of Interpretation, Museum of Photography at George Eastman House, Rochester, New York, USA: "It is important that cultural heritage conservators trust the accuracy and integrity of their tools. Technology from Leica Microsystems, known worldwide for its refined image quality and optical perfection, inspires confidence in the precision and consistency of our professional judgement."

Geneviève Aitken, responsible for documentation studies, new information technologies at the Centre de Recherche et de Restauration de Musées de Louvre, Paris, France: "The Leica Microsystems technology helps enormously and opens new opportunities for restoration and conservation of old photographs and documents."

Frank Grossmann, CEO Colour-Science AG, Bäretswil, Switzerland: "The Leica M205 C microscope adds superior quality in the research and diagnostic field thanks to its top notch features."



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Stereomicroscope Reveals Destructive Work of Marine Sponge

Antique Underwater Treasures Endangered

Kerstin Pingel, Leica Microsystems



In the 2nd century BC, Baiae in the Gulf of Naples was a notorious bathing resort and spa for wealthy Romans. Today, part of the town is submerged under the sea and can be visited as an 80,000 square metre archaeological underwater park. The magnificent mosaics from the underwater ruins are analysed at the Istituto Superiore per la Conservazione e il Restauro (ISCR) of the Ministry for Cultural Heritage and Activities in Rome: Using a Leica stereomicroscope, scientists track down the activities of an endolithic sponge that is threatening to gradually destroy the antique limestone tesserae.

Baiae's rise to fame as a luxury spa of the Roman élite began in the 2nd century BC. The volcanic soil not only provided excellent growing conditions for olives, chestnuts, fruit and wine, but also hot mineral springs and sulphur vapours in abundance – and since Hippocrates, these were well known for their power to heal all kinds of ailments. Wealthy Roman citizens, senators and emperors came to Baiae, built splendid villas and thermal baths, enjoyed bathing in the hot springs and indulged in a sensuous life, as some antique authors criticised. However, the same volcanic activity that brought fame to Baiae was also responsible for its demise. The geological phenomenon of bradyseism (the uplift and subsidence of ground in a volcanic area) caused the entire coastal region at the Gulf of Naples to sink six metres in the year 300 AD: Baiae and its palaces disappeared in the sea. Today, the sea is giving back some of the antique ruins, as the sea bed is rising several millimetres a day.

Animals bore tunnels and holes

Gianfranco Priori, member of the “Nucleo per gli Interventi di Archeologia Subacquea” of the ISCR, studies the mosaics the wealthy villa owners used to decorate their floors and walls together with a multidisciplinary team of archaeologists, chemists, architects, conservators and biologists. Made of limestone tesserae, the ancient works of art are obscured by thick colonies of animal and vegetable organisms that are gradually destroying the material. The sponge *Cliona celata* is causing particularly invasive bioerosion. This sponge uses acid secretions to bore tunnels in calcium carbonate in which the animal then lives.

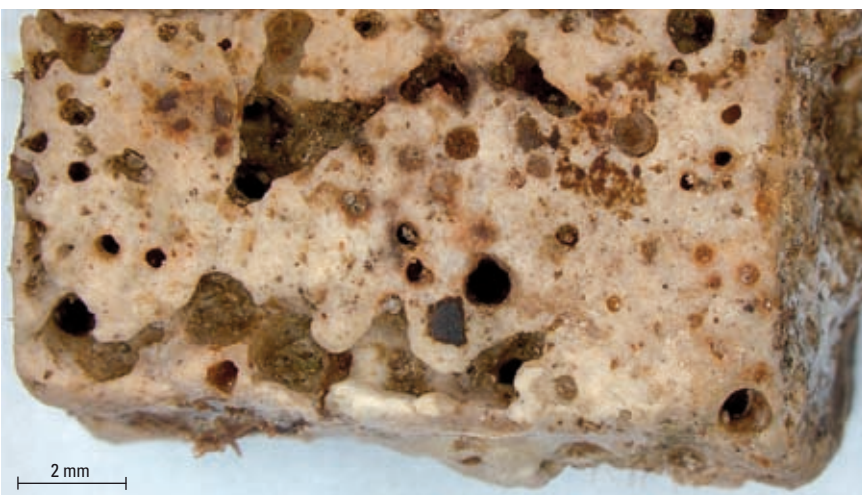
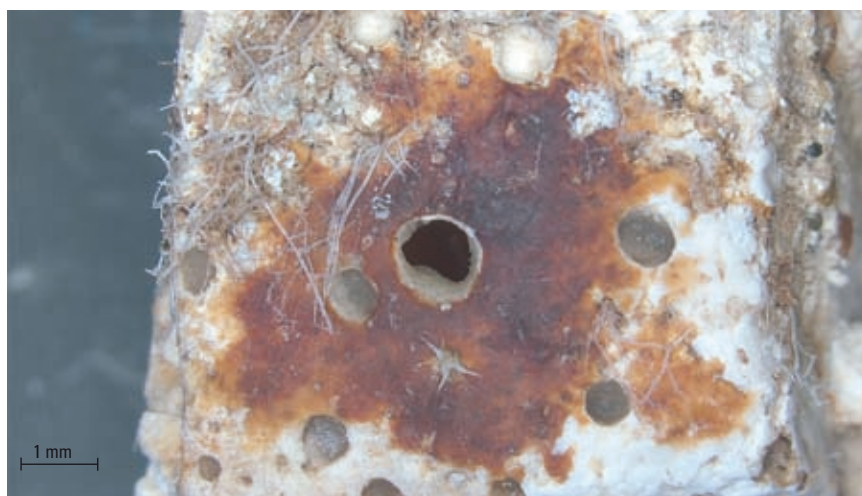


Fig.1, 2: Stereomicroscopic images of tesserae sections showing the system of holes and tunnels made by the endolithic sponge.

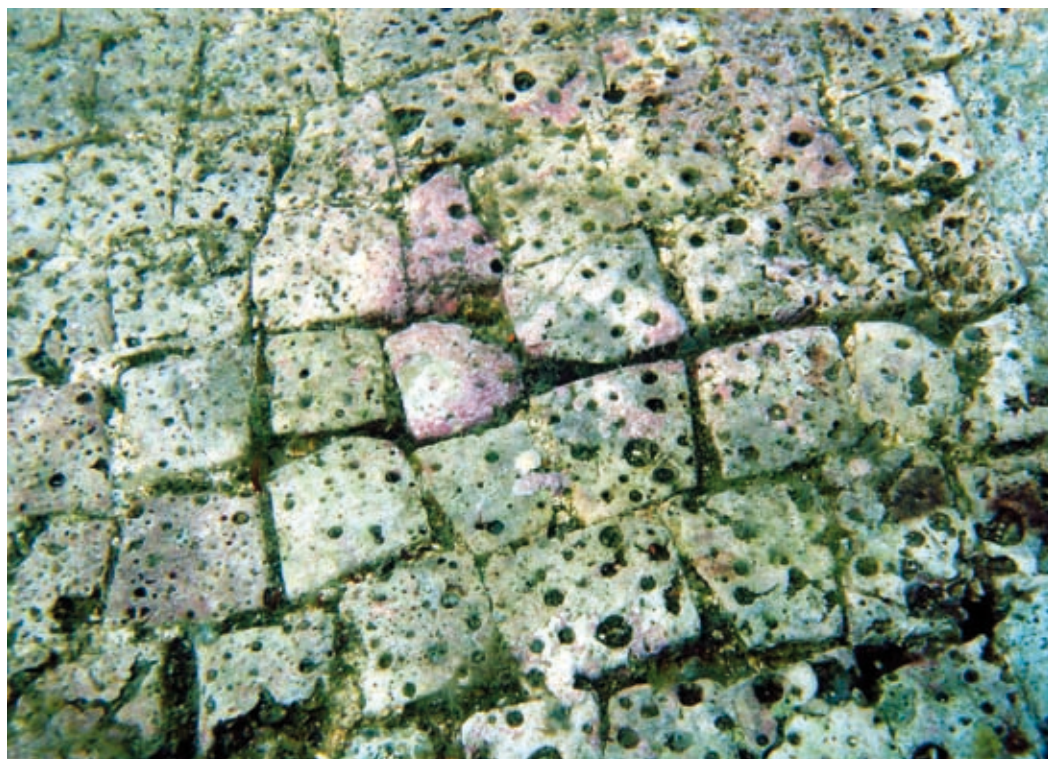


Fig. 3: Mosaic floor in the underwater park of Baiae: The limestone tesserae show distinct signs of destruction by *Cliona celata*.

Microscopic vision reveals destruction

"On the surface, the bore holes are almost imperceptible," says Priori. "Only when we examine them under a microscope in the lab can we see the real state of decay." To document the visual state of the mosaics and take samples of the tesserae, the scientists have to view them in situ – that means underwater. First, they take photos at a depth of five to seven metres with the underwater camera. The samples taken there of the antique limestone mosaics are then examined in the laboratory with an electron microscope, a Leica research microscope and a Leica MZ16 stereomicroscope with integrated camera. The stereomicroscope visualises both the bore holes at the surface and the interior penetration pattern of the sponge.

The Leica IM1000 digital imaging software is used to count the borings and measure their diameters. "It was the stereoscopic examination that showed that the state of the mosaic plates is worse than was to be expected from looking at the surface," Priori sums up. Morphological analysis of the tesserae reveals a system of interconnected holes and tunnels whose dimensions are far greater than the bore holes visible on the outside of the sample. Curiously, the number of interior cavities is in no direct relation to the number of bore holes on the surface.

"In our investigations, we not only benefited from the optical qualities and high resolution of the Leica MZ16, but particularly from the perfect interface

between the stereomicroscope and the Leica IM1000 imaging software," says Priori, who is responsible for microscopy and photomicrography in the laboratory. "In addition, the Leica Application Suite software with the Multifocus module extends the microscope's depth of field many times over."

New method for retarding bioerosion

The study of the ISCR is one of the first works on the impact of marine endolithic organisms on historical works of art located under water. The examinations are now to be extended to other types of stone such as white or multicoloured marble. "The most significant result of the work we have done so far is the development of a method for retarding bioerosion," comments Priori. In the winter months, when fewer tourists come to Baiae, the mosaics will be covered with a geofabric that limits the water flow and sun radiation on their surface and restricts the settlement and growth of many animal and vegetable species.

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Fig. 4: Gianfranco Priori uses the stereomicroscope to examine the bore holes on the surface and also the interior penetration pattern of the sponge.



Fig. 5: In the winter months the endangered mosaics are protected by a geofabric.

Inclusions in Gemstones

Exclusive Aesthetics of Nature

Michael Hügi, M.Sc., Swiss Gemmological Society

Gemstones have fascinated people for thousands of years. Rulers and kings used to demonstrate their power and wealth with jewel-studded insignia. Although fine jewellery is still a status symbol of the rich, we now tend to treasure these wonders of nature more for our own pleasure in beauty and harmony. The place where aesthetics of the mineral world and science meet is the domain of gemmologists. In modern gemmological laboratories, microscopic examination of the interior and surface characteristics of a gemstone is still the mainstay for assessing quality criteria.

- **Syngenetic inclusions:** These were formed at the same time as the host crystal, e.g. fractures that have been healed. A lot of small cavities were formed in the process, so-called negative crystals, which contain remains of the aqueous solution in which the crystal grew.
- **Epigenetic inclusions:** Inclusions originating after the formation of the host crystal. These are mostly natural substances within fissures or exsolution products in the host crystal.

Two of the most important tasks of the gemmologist are determining the genuineness and the quality of a gemstone. He identifies an unknown stone by measuring its optical and physical constants; he determines the authenticity and origin of the stone and its possible treatments to improve the optical appearance. The inner characteristics of a stone reflect the chemical and physical conditions during its growth in its natural surroundings – or, in the case of synthetic materials, in the laboratory. Such characteristics may be colour zones or natural intergrowth of two or more individual crystals according to crystallographic laws, also known as twinning. Often, foreign substances are included in gemstone minerals. Such inclusions are differentiated according to type:

- **Protogenetic inclusions:** Minerals already present before the host crystal formed and enclosed these minerals.

Microscope reveals hidden beauty

It is not necessarily true that a good gemstone has to be a hundred per cent clean and that inclusions are “defects” that diminish its value. In the case of faceted diamonds, the clarity of the stone is indeed a key criterion judged by a standardised nomenclature. For all other gemstones and ornamental stones, however, inclusions do not reduce their value provided they do not impair the stone’s appearance or stability. In fact, they make the stone unique and accentuate its exclusiveness – they are, as it were, nature’s signature. Apart from their scientific significance, the unique aesthetics of inclusions can often only be seen through a microscope. In view of this hidden inner beauty, the term “defect” assumes a positive rather than a negative meaning.

The microscopic examination of gemstones places great demands not only on the gemmologist but also on the instrument. As it is mostly stones set in jewellery that are examined, possibilities of observing inner characteristics are often limited. In some cases, immersion in liquid with light refraction similar to that of the stone can help. Extreme differences in contrast against a dark background, for instance due to reflecting facets or inclusions with metallic lustre, are also a considerable challenge for the illumination.

As a rule, stereomicroscopes with the following illumination techniques are used for gemmological examinations:

- **Diffuse brightfield:** This illumination enables observation of low-contrast growth structures, colour zoning and fluid inclusions. If crossed polarisers are used, it is possible to identify birefringent mineral inclusions or lamellar twin plains.

Fig. 1: Inclusions probably of melanterite (hydrous Fe sulphate) in rock crystal (quartz), found at Minas Gerais, Brazil. It is a pseudomorphs after the iron sulphide marcasite, which is also found as inclusions in quartz in the same deposit. Transmitted light, crossed polarisers.



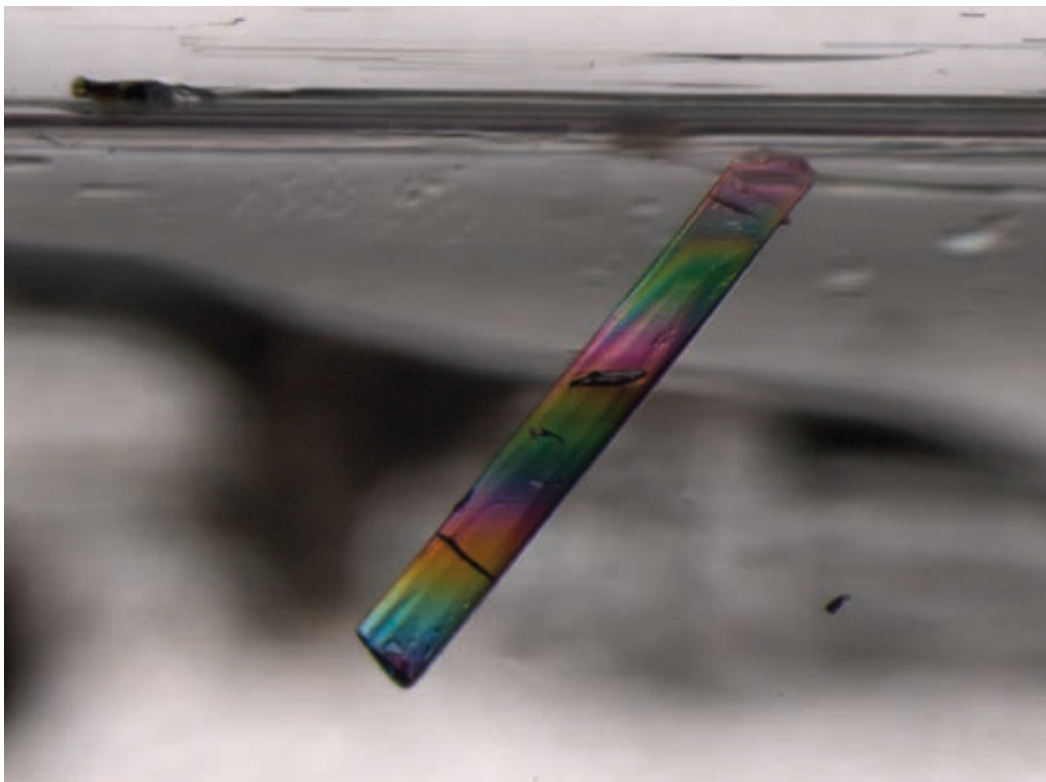


Fig. 2: Inclusion of a tourmaline crystal in aquamarine (variety of beryl), found in Northern Pakistan. The interference colours of the tourmaline needles are due to the polarised light. Width of image: approx. 1.5 mm, transmitted light, singly polarised light.

- **Darkfield:** Darkfield illumination shows up extremely fine structures such as needle-shaped or hairline inclusions that are not visible in brightfield.
- **Glass-fibre optical waveguides:** They enable a targeted darkfield illumination, or are used with incident light for the examination of surface structures.

For images like the ones illustrated in Figs. 1 – 6 the Swiss Gemmological Society uses a Leica MZ16 stereomicroscope with a Planapo objective 1.0x, which provides an adequate free working distance for examining even large objects. Illumination for bright-field or darkfield is supplied by a cold light source by Leica Microsystems. In addition, two glass-fibre waveguides with an external light source are used. As many gemstones are optically anisotropic, i.e. birefringent materials, a polarisation filter (analyser) is generally used to eliminate image blurring due to birefringence.

Digital photomicrography of inclusions

The documentation of inner characteristics of gemstones with the aid of photomicrography dates back to the 19th century. The German mineralogist Ferdinand Zirkel mentions this technique in 1873 in his book "Die mikroskopische Beschaffenheit der Mineralien und Gesteine". All the same, Zirkel regarded photomicrography with some scepticism. Compared

with the technique of drawing, he was of the opinion that photography offered no possibility of highlighting important parts of the image or omitting insignificant detail. Despite this supposed inflexibility, photomicrography became an indispensable instrument in gemmology as in other sciences. Gemmologists such as the Swiss professor Eduard Gübelin, one of the founders of the Swiss Gemmological Society, and the American J. Koivula played a major role in the

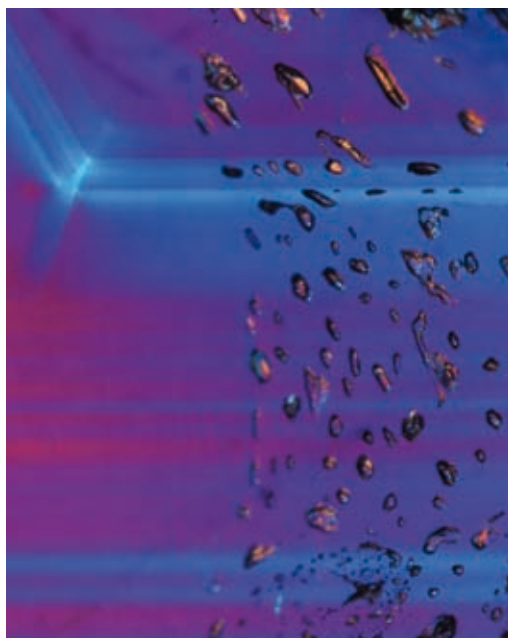


Fig. 3: Fluid inclusions and growth zoning in aquamarine (variety of beryl), found at Mina Padre Paraiso, Minas Gerais, Brazil. During the growth of a crystal in an aqueous solution, stress can cause the formation of fractures that heal as the crystal continues to grow. In the former fissure, remains of the original aqueous solution are sealed in cavities, the so-called negative crystals. These fluid inclusions are located in the plane of the former crack. Their contents separate in different phases as the stone cools down after crystal growth. In the illustrated sample, all inclusions contain a gas bubble (CO₂), liquid CO₂ and a small amount of water. Width of image: approx. 3 mm, transmitted light, crossed polarisers, first-order red compensator.

The Main Gemmological Examination Methods

As a general rule: Gemmological examination methods must not be destructive.

Standard equipment

- Gemmological stereomicroscope
- Refractometer (determination of refraction index)
- Hydrostatic balance (determination of weight and specific gravity)
- Spectroscope (optical observation of absorptions in the spectrum of visible light)
- Polariscope: determination of optical anisotropy
- Dichroscope: determination of pleochroism (differences in colour depending on the vibration plane of the polarised light)
- UV lamp: observation of fluorescence

Analysis techniques in modern gemmological laboratories

- Spectral photometer, UV-VIS and IR (exact measurement of absorptions in the UV to visible light range and in the infrared range)
- X-ray fluorescence (XRF): semi-quantitative analysis of trace elements
- Raman spectroscopy: analysis of molecular structures (e.g. determination of inclusions)
- Laser-ablated – inductively coupled plasma – mass spectrometry (LA-ICP-MS): highly sensitive trace element analysis
- Scanning electron microscopy (examination of submicroscopic surface structures)
- Laser induced breakdown spectroscopy (LIBS): further trace element analysis

further development of inclusion photography with black-and-white and colour film. Their techniques are still used in today's age of digital photography. High-quality optics, careful work and a lot of patience are the preconditions for good photomicrographs, as the special characteristics of inclusion microscopy pose a considerable challenge. In particular, strong contrast, limited field depth as well as unnoticed specks of dust or scratches on the surface of the stone often create problems. As with microscopic analysis, different illumination techniques and, most importantly, their combination, are crucial for the results of photography.

Processing without falsifying

Digital photomicrography, which has gained general acceptance over the last few years, opens up new possibilities for inclusion photography. Using the technique of High-Dynamic-Range Imaging (HDRI), photos can be produced of objects whose dynamic range of luminance between light and dark areas exceeds the limited luminance range of the photo sensor of the camera. HDRI photos are generated in the computer from a series of bracketed exposures, so that the full contrast range is stored in one 32-bit image. However, this image cannot be reproduced

Fig. 4: Rock crystal (quartz) and rutile needles enclosed in rock crystal (quartz), from Minas Gerais, Brazil. Because of the light metallic lustre of the rutile needles (titanium oxide, TiO_2), the trade name of this quartz variety is "platinum quartz". The picture shows a first generation rock crystal inclusion that was enclosed by a second generation of quartz. Although the inclusion and the host material have the same refractive index, the enclosed quartz is easily recognisable due to a thin film of air at the interfaces. Width of image: approx. 6 mm, transmitted light, crossed polarisers, first-order red compensator.





Fig. 5: Fluid inclusions and inclusions of rutile needles and small siderite crystals (iron carbonate) in rock crystal (quartz), found at Minas Gerais, Brazil. The irregular cavities formed by growth contain remains of the aqueous solution in which the rock crystal grew about 500 million years ago. The bright interference colours of the otherwise colourless quartz are formed by the almost parallel viewing direction to the optical axis of the crystal in polarised light. Width of image: approx. 6 mm, transmitted light, crossed polarisers.

either on conventional monitors or with printing techniques. To obtain a realistic image corresponding to the visual impression with distinct highlights and shadows, a second step, so-called tone mapping, is carried out by compressing the luminance range to produce an 8-bit image that can be reproduced with conventional media.

Computer-aided postprocessing of the digital images offers the opportunity to overcome certain restrictions imposed by the still limited photographic technique and to obtain a more realistic picture. However, this tempting opportunity must not lead to retouching or colour changes that deliberately falsify the information provided by the image. In this respect, Ferdinand Zirkel is still right today: The author should use his possibilities of influence – whether with a drawing pen or image processing software to help document reality in an understandable way.

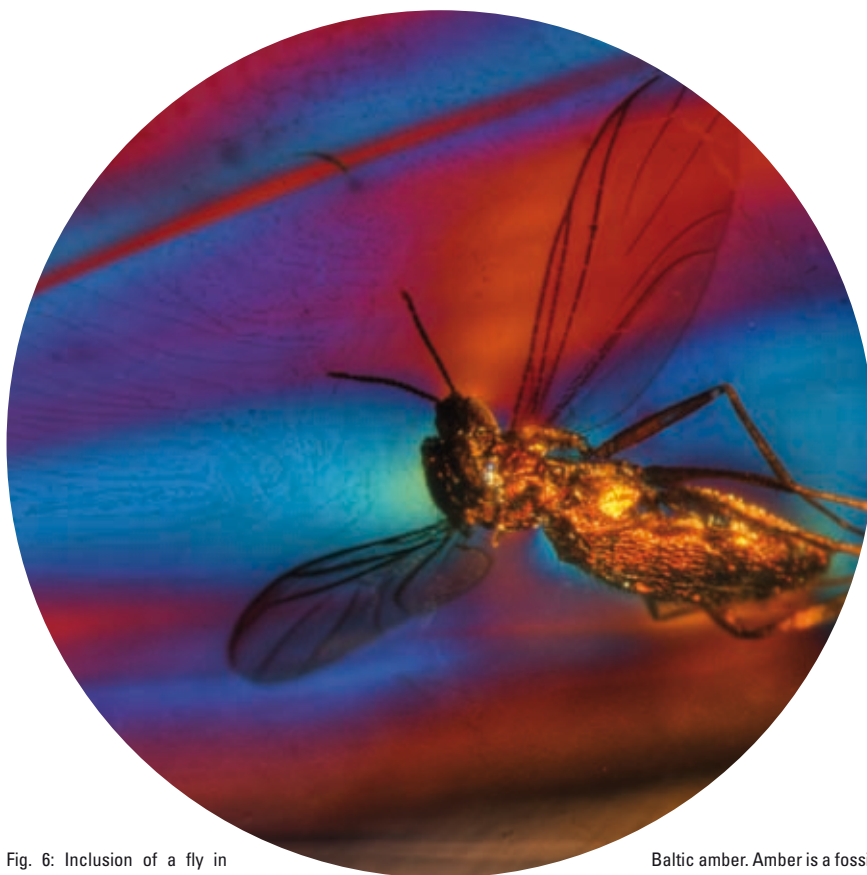


Fig. 6: Inclusion of a fly in resin, and this sample originated forests in what is now the Baltic region.

Amber occasionally contains inclusions of insects, spiders, small vertebrates, etc., which stuck to the resin and were covered by subsequent resin layers. Thus they have been excellently preserved. After the tree died, the lumps of resin were washed into rivers and then into the sea, where they were embedded in sediment and fossilised. Although amber is an amorphous substance and in theory optically isotropic, the flow structures of the resin due to internal strain as well as the strain caused by the inclusions can be visualised in polarised light. The use of polarised light and the first-order red compensator lead to intensive colours in the otherwise golden amber. Combination of darkfield and incident light (glass-fibre), crossed polarisers, red-1 compensator, HDRI tone mapping.

Baltic amber. Amber is a fossil about 35 – 40 million years ago in

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Leica F12 I – New Floor Stand for Restorers

The Mobile Solution for Large Objects

Meinrad Berchtel, Leica Microsystems

Paintings, sculptures or furniture – art treasures are rarely small enough to fit under a conventional microscope for restoration and preservation work. That's why Leica Microsystems designed the Leica F12 I. Combinable with a stereomicroscope and a digital camera, this new floor stand is especially geared to the needs of art restorers, providing flexibility and convenience with an excellent price-performance ratio.



Movable in all directions

The new Leica F12 I floor stand can be flexibly adapted to a wide variety of working conditions and situations, whether at an easel, in front of a wall or at a table. Equipped with three pivots and stepless height adjustment, the stereomicroscope can be ideally aligned to any detail in need of examination and restoration. In addition, the horizontal arm can be rotated through 360° round the vertical column.

Flexible in any situation

The focusing arm is compact and ideal for working on either vertical or horizontal surfaces. To view the work of art from the side, the tiltable column is quickly and easily set to the desired viewing angle without the need for any tools.

The maximum arm reach of the Leica F12 I is 120 cm. Benefiting from Leica's many years of experience in designing surgical microscopes, the new floor stand offers such high stability that vibrations are kept to a minimum despite the length of the swing arm.

Brilliant in every respect

The floor stand can be combined with any Leica stereomicroscope in the modular M series or the compact S series. All Leica stereomicroscopes feature high-quality optics that allow detailed three-dimensional magnification of the structures of interest.

Hours of comfort

The floor stand is easily adaptable to the posture of the user to reduce fatigue and prevent cramp in neck and back muscles even after hours at the microscope. In particular for matching viewing height and angle to the height of the user, a few millimetres make all the difference for the correct body posture. Leica Microsystems therefore offers a wide range of ergonomic accessories for stereomicroscopes, for example an Ergo binocular tube with variable viewing height.

In the right light

Two factors are often critical for art restoration: The microscope image must show the colours as they really are and the surface of the work of art must not be warmed up by the illumination. Leica LED illumination modules are ideal as they radiate neither UV nor infrared light and their colour temperature is very close to that of daylight.

Discussion and documentation

To document examination results and restoration work, the Leica F12 I can be combined with a microscope camera and corresponding image analysis modules. Integrated between the zoom optics and the body tube, the compact Leica IC80 HD high-definition digital camera has an HDMI port that enables images to be displayed on a monitor in full HD quality – a great advantage for discussing further procedure with colleagues, for example. The Leica IC80 HD can store the images directly on an SD memory card without a computer.



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FusionOptics™ – The New Dimension of Stereomicroscopy

Nature's Ingenuity Shows the Way

Daniel Göggel and Anja Schué, Leica Microsystems

In recent decades, the neurosciences have gained many insights into the complex processes by which our brain does the fascinating job of processing the signals originating from the eyes into an image. A study on visual perception carried out jointly by Leica Microsystems and the Institute of Neuroinformatics at the University of Zurich and Swiss Federal Institute of Technology provided the basis for an innovation in stereomicroscopy which, in terms of resolution and depth of field, has broken through limits that were previously impossible to overcome.



Fig. 1: The Leica M205 C high performance stereomicroscope is based on FusionOptics™.

Stereomicroscopy enables us to view microstructures in 3D with the help of two separate beam paths – which, in principle, work like an extension of our two eyes. For over a century, optics designers have worked to push magnification, resolution and image quality to the limit permitted by optical principles.

These limits are determined by the correlation between resolution, convergence angle and working distance. The higher the microscope resolution, the higher the convergence angle between the left and right beam paths and the lower the available working distance. However, increasing the distance between the optical axes would cause a distorted 3D image. A greater zoom range alone is of little use, since with increasing magnification, there is not an attendant increase in optical resolution. The result is what is known as empty magnification.

Limits are made to be broken

Scientific studies have shown that the brain can selectively process information from individual eyes and that it is very capable of compensating for differences in the visual acuity of the two eyes. This gave the engineers at Leica Microsystems a simple but ingenious idea. Why not make use of this ability of the brain and use each beam path of the microscope for different information? One image channel provides high resolution, the other depth of field. The two very different images are merged to a single, optimal spatial image by the brain. This completely new optical approach – FusionOptics™ – brings with it two distinct advantages. Compared to existing stereomicroscopes, the resolution can be increased drastically and the focus depth can be improved significantly.

Scientific study confirms new approach

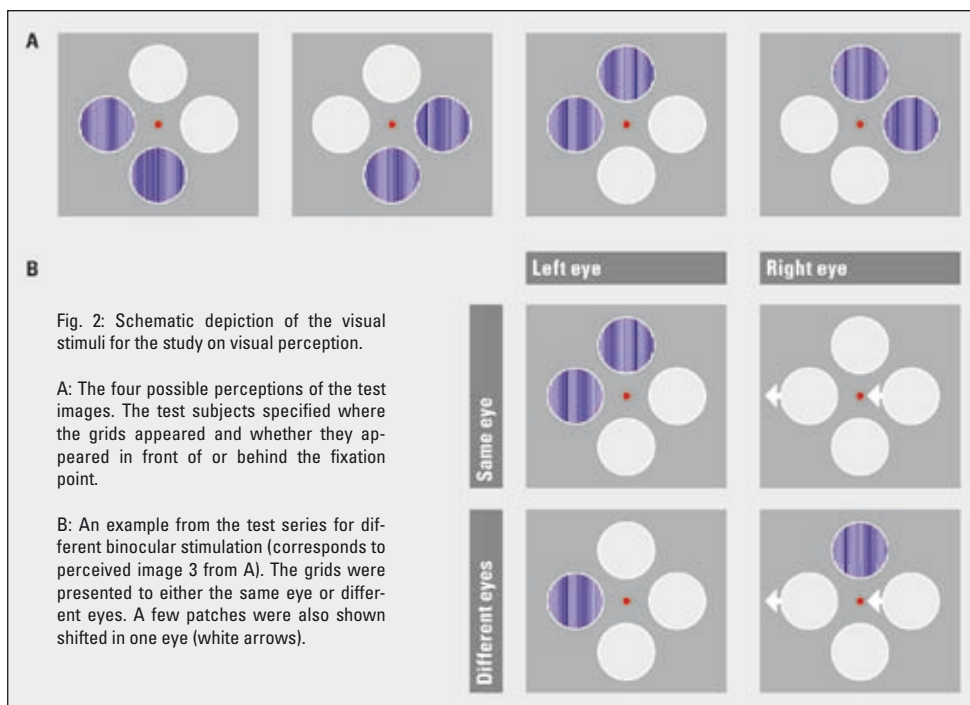
Dr. Daniel Kiper of the Institute of Neuroinformatics at the university of Zurich and Swiss Federal Institute of Technology, who specialises in researching signal processing in primate brains, designed a study along with Graduate Assistant Cornelia Schulthess and Dr. Harald Schnitzler of Leica Microsystems. Of particular interest was whether an interocular signal suppression takes place when both eyes are exposed to different stimuli.

Test subjects observed grid and uniform patches arranged around a central fixation point (Fig. 2). To create differences in the spatial perception of both eyes, special stereo goggles were used with which separate test images can be projected to each eye. The test subjects saw changing arrangements of the grid patches in various depth planes.

No evidence of signal suppression was observed in the experiments. This means that the human brain is capable of using the best information from both eyes in order to compose an optimal spatial image. This is true regardless of whether the images are acquired using both eyes or each eye provides entirely different information.

FusionOptics™ provides one-of-a-kind 3D images

The Leica M205 C with FusionOptics™ is the world's first stereomicroscope with a zoom range of 20.5:1 and a resolution of up to 525 lp/mm. This corresponds to a resolved structure size of 952 nm. When appropriately configured, this can be increased to up to 1,050 lp/mm (structure size of 476 nm). In addition the large



working distance of the new objective generation allows convenient freedom of movement for examining specimens on the microscope stage.

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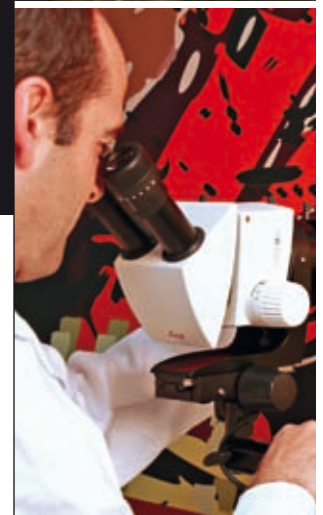
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