WESTERN MEDIEVAL WALL PAINTINGS

Studies and Conservation Experience

Sighisoara, Romania
31 August
3 September 1995

ICCROM

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STUDIES AND CONSERVATION EXPERIENCE

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FOREWORD

A conservation workshop on problems of "Western Medieval Wall Paintings" was organized in partnership by ICCROM, the Romanian Ministry of Culture and ICOMOS-Germany. The event took place in Sighisoara, a small, well-preserved historic town in the heart of Transylvania, Romania, in July-September 1995.[1]

A group of 19 young conservator-restorers from different European countries attended, all with working experience on wall paintings of the Romanesque and Gothic periods, found in a broad historico-cultural region ranging from northern Spain and Italy to Scandinavia, and reaching as far east as Transylvania, on the borders of the Byzantine empire.

Participants were involved in the examination and the development of suitable conservation measures for the early 16th-century paintings of the "Church on the Hill," which dominates the fortified citadel of Sighisoara.

Numerous experts from various disciplines joined the course at different times, delivering lectures, presenting the results of relevant research and stimulating the interchange of ideas and experience.

The course ended in a three-day seminar, organized on site. This publication is intended to make available the proceedings of this meeting, which was a highlight of the training programme. Nine senior wall painting conservators, selected from a larger group of experts who responded positively to a call for papers, presented their studies and personal conservation experience on western medieval wall paintings.

Most of the speakers were former participants of the international course on mural painting conservation, organized by ICCROM in Rome since the late 1960s. They demonstrated their ongoing interest and idealism towards

Sighisoara, Romania. The Church on the Hill (Biserica din Deal), seen from the citadel.

ICCROM's activities by accepting our invitation to Romania, partly at their own expense. Another important contribution to the seminar was the participation of the Conservation of Wall Painting Department of the Courtauld Institute, London, which has a particular expertise in the field.

The seminar papers cover a wide range of case studies and a broad geographic distribution. They offer many contributions towards a better knowledge of historic painting techniques and discuss a variety of issues related to the complex task of preserving the few examples of medieval wall painting that still survive in Europe.

A specific feature of this publication is that it gives a voice to wall painting conservators, the professionals with the highest day-to-day responsibility for the correct preservation of the values of this painted heritage. Despite their vast scientific and empirical experience, these hands-on practitioners are usually rather silent, and are certainly under-represented at most expert meetings.

Werner Schmid
Coordinator, MPC Romania 95

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1 In addition to funds from ICCROM and the Romanian Ministry of Culture, the project was financially supported by generous grants from the UNESCO World Heritage Fund, the Commission X of European Communities and the Messerschmitt Foundation, Germany. The Academy of Fine Arts, Bucharest, made available the staff of the wall painting conservation department and equipment for setting up a field laboratory.

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THE ROMANESQUE PAINTINGS OF SAINT-SAVIN-SUR-GARTEMPE AND THE RESTORATION OF THE CRYPT

Isabelle DANGAS

ABSTRACT

The four major cycles of Romanesque paintings in the abbey church of Saint-Savin (France) – those of the porch, the tribune, the nave and the crypt – are herein invoked historically, iconographically but most especially in terms of their execution or proper conservation. This commentary is the result of an interdisciplinary effort. It was elaborated both prior to treatment of the works themselves and in the course of their restoration. The crypt, which has just been fully restored, receives particular attention.

Keywords: composition, cycle, disinfection, maintenance, micro-organism, mortar, mural painting, ornament, pigment, Romanesque, technique of execution, treatment.

Saint-Savin, 40 km west of Poitiers, is a small town situated on the river Gartempe. Its abbey, an architectural, sculptural and pictorial landmark of the Romanesque period, was classified as a World Heritage site by UNESCO in 1984.

For the past ten years, I have been entrusted by the Ministry of Culture with examining and restoring several of St Savin's pictorial cycles.[1]

HISTORICAL SOURCES

Because of the destruction of St Savin's charter room in the 16th century, there is a good deal of uncertainty about the foundation and development of this prestigious monument.

The abbey's origin dates from the 9th century. It soon came under the protection of Charlemagne and his son, King Louis-le-Pieux. The latter charged Saint Benedict of Aniane with reformation of the community.

The construction of the current abbey church and its decoration was undertaken in the 11th century.

The monument's complex and fluctuating history cannot be covered in this paper, but the salient facts can at least be outlined. Periods of great glory were followed by ones of obscurity, such as during the Hundred Years War, religious strife and periods of occupation when the church was desecrated. These times led to the damaging of the church and the destruction of its dependencies.

In the 17th century, thanks to King Louis XIII, the abbey flourished again. The Congregation of Saint Maur could then re-establish its monastic discipline and restore the historic fabric.

With the French Revolution, severe material damage ensued.

In the 19th century, Prosper Mérimée protected and restored both the monument and its paintings.

A series of restorations was carried out, the most recent of which done by myself in 1995.[2]

THE PAINTINGS

St Savin's paintings are considered both the most beautiful and the most comprehensive Romanesque pictorial sequence in France.

The different iconographic cycles which adorn large parts of the church are dated towards the end of the 11th century. They are divided into four main groups: the porch, the tribune, the nave and the crypt. These decorations, judging from their stylistic unity, seem to have been executed in a

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relatively short time (a few decades?), soon after the construction and possibly by the same workshop.

At first glance, one might detect disparities. One must, however, consider each pictorial situation according to the light and scale imposed by the given architectural context. In the porch and crypt, the dimensions call for tiny figures (0.75 m to 1 m), while in the nave or the tribune they allow for larger ones (2 m and 3 m).

From an iconographic point of view, it is curious that the programme starts at the end: in effect, upon entering, the visitor is confronted by tumultuous episodes from the Apocalypse and faced by a Christ in glory, while the Passion and Resurrection (fundamental to dogma) are isolated in the tribune, out of view and scarcely accessible.

Let us pass briefly through the different cycles and then concentrate on the crypt, which has recently been restored.

The Porch

Iconography

Through the western entrance, we enter a dark room decorated on its barrel vault with scenes of the Apocalyse and with a Christ in Glory on its tympanum.

This Risen Christ, seated on his throne, is surrounded by an aureole. He has his arms raised and his right hand posed in a Byzantine blessing (thumb and ring-finger joined). On all sides, angels are carrying instruments of the Passion, whose cross is here an object of glory.

Adoring angels and apostles are represented on the overhanging arch, twelve figures in groups of three.

On the western double arch are figured the signs of the zodiac, of which only Aries, Libra and Scorpio remain.

Among the visions of the Apocalypse, the following scenes are found on the northern side:

- The fifth angel (Rev 9: 7-9), while sounding the trumpet, opens the well of the Abyss, from whence locusts escape. Their mission is to torment, for five months, those without the seal of God on their forehead. Crowned, winged, represented as horses with human heads and lion's teeth, they are seen rushing upon the damned.
- Another scene, just below, represents two episodes: John detecting the Ark of the Covenant (Rev 11: 19) and, on his right, a woman in childbirth being attacked by a dragon, while, at the same moment, the child is rescued by an angel (Rev 12: 1-5, 15-16).
- The lower register illustrates the New Jerusalem; the founders of the abbey can be seen in the audience.

The ornaments

- Chromatic bands (yellow and red) frame the scenes. They are adorned with white bars, beads and small parallel lines.
- Friezes of different orders follow the line of the arches; marble imitations, fret motifs, trails of foliage or checker-boards adorn the mid barrel vault.
- The inscriptions, in running sentences located horizontally between registers, have almost all disappeared.

Some technical elements

The plaster, composed of lime and sand, is applied in *pontate.*

The preparatory design is freely realized with diluted red ochre. The compositional axes are impressed in the fresh *intonaco* (by snapping cords loaded with red pigment).

The technique is mixed, beginning *a fresco* and terminating *a secco.* It cannot be determined whether the casein, detected in the analysis, is original or belongs to a later restoration.

The palette is clear, with occasional black (charcoal), used pure or mixed with white and red ochre; white (calcium carbonate), used pure or mixed with different pigments; yellow and red (ochres); minium; green earth; and lapis lazuli applied on a grey layer.

The upper background (symbolizing the sky) is represented in one of two ways: either in white, or in blue with a strip of green (as opposed to the crypt, where green predominates). These two colours have almost disappeared today. The lower background (representing the earth) is mostly composed of two large bands, one of which is striped and the other monochrome, with delicate flowers.

This cycle displays a rich iconography and a great unity of style and chromatic harmony. Note, too, the beautiful representation of faces and hands and the graceful motion of the angels in the double arch.

Figure 1. St Savin.The porch. John detecting the Ark of the Covenant and a woman in childbirth being attacked by a dragon (Rev 11: 19). (All photographs by the author)

Figure 2. St Savin. The porch. New Jerusalem. Detail: faces of the founders of the abbey.

Among the factors of alteration

The degradation caused by salts, especially that of sodium carbonate, and a microbiological attack (algae, fungi and bacteria) can be cited as the major factors of alteration.

The Tribune

Iconography

Situated upon the porch, this high narrow room is lit from the west by windows and from the east by a large bay opening onto the nave.

The Passion and the Resurrection cycles adorn both the walls and vault. Today, they are partly effaced, especially to the west. This art, relatively static, displays nonetheless a beautiful style and sense of composition as exemplified in the Descent from the Cross. The peculiar elongation of figures in the tribune shows how well the artist has adapted his subject matter to the given space; they are free to grow larger as they approach the top registers.

The ornaments

- The scenes are separated with chromatic bands (yellow and red), adorned with white bars, beads and small parallel lines.
- Friezes of different orders follow the eastern arches: fret similar to that of the porch, trails of foliage, or marble imitations, such as in the porch and crypt.
- The lower background (representing the earth) is mostly composed of two large bands, one striped, the other monochrome, with delicate flowers.
- The inscriptions, in running sentences, located horizontally between registers, or close to the figures, have almost disappeared.

Some technical elements

The plaster is composed of unsifted sand and lime, with elements different in size, nature and colour, including lime, mica and charcoal. It is applied in pontate. Cords marked the mortar in different ways: horizontally, vertically or obliquely. Some were loaded with red ochre. The preparatory drawing is freely sketched with diluted red ochre. The compositional axes are printed in the fresh intonaco (cords loaded with red ochre). No incisions have yet been detected.

The technique is mixed, started in fresco and largely finished a secco. Casein, detected in analysis, seems to be a product of restoration.

The palette is composed of charcoal, calcium carbonate, yellow and red ochres, minium, green earth and azurite.

Among the factors of alteration

A microbiological attack is detected from a white veil, filaments, spots and confirmed by analysis at the Laboratoire de recherches des monuments historiques (L.R.M.H.). Green and pink algae, but mostly fungi: *Aspergillus fumigatus* is particularly dangerous and rapidly propagates.

Analysis of salt contamination reveals the presence of calcium carbonates, nitrates and sulphates, and potassium nitrates.

The Nave

Iconography

The central nave is supported by huge columns adorned with imitation marble. Its barrel vault and pendentives are covered with luxuriant paintings, 42 m long and 11 m wide, i.e., a total surface of 462 m^2. The programme represents the prophets in the pendentives and unfolds, on the vault, in a series of 50 episodes from the New Testament – the books of Genesis and Exodus.

At first, the sequence appears peculiar: The Creation and the Fall, Cain and Abel, Enoch, the Tower of Babel, Abraham, Jacob, Joseph and Moses.

Nevertheless, this programme corresponds to exegesis and medieval symbolic rules: in fact, only the condemned face westward (Cain, Ham and the kings defeated by Abraham), while the blessed are turned toward the altar. Note, too, that the eastern scenes are highly symbolic: they celebrate, for example, bread (Joseph selling his loaves to Egyptians) and wine (Noah pruning his vine and drinking of its fruit).

In conclusion, one might ask if this apparent disorder is not guided by a hidden thread: perhaps the "Letter to the Hebrews" (11: 1-29) in which Abel, Enoch, Noah, Abraham, Jacob, Joseph and Moses are mentioned in turn, thanks to their exemplary faith.

The ornaments

- Chromatic bands (yellow and red), frame the scenes; they are adorned with white bars, beads[3] and small parallel lines.
- Friezes of different orders are employed: the axial band with a plaited ribbon, arches with discs (elements similar to those in the crypt)

Figure 3. St Savin. The nave. Noah's Ark.

and trails of foliage (elements similar to those in the tribune and porch).

- The inscriptions – sentences displayed between registers or close to God and figures such as Abraham or Noah – have almost disappeared.

Some technical elements

The paintings present different styles and techniques, and art historians have recognized therein the work of several artists. The present paper does not attempt to develop this matter. I can only suggest an approach in terms of technique. The paintings are mostly executed a secco. Plaster is applied in pontate, across the upper third of the scenes. Compositional axes are impressed in the fresh intonaco in order to underline horizontal bands or certain vertical chromatic limitations/boundaries.

For the preparation, a free sketch is made with diluted red ochre. Some examples can even be seen in transparency; while others, such as Noah's head, have been disengaged during a late restoration.[4] Fine indirect incisions define the drawings; some are elaborated with crossed marks.

Figure 4. St Savin. The nave. Cain's Offering. Detail semi-visible because of the 1970s restoration, with first and last version.

Pigments are applied gradually, sometimes directly on the mortar (first bays) or, more often, on a limewash.

The *pentimenti* are numerous: for example, in Abel's Gift, a primitive composition represents God's hand, while the final realization represents God in person, receiving Abel's Gift. Another example is shown in Cain's Offering: the initial composition depicted a head, while the final version shows a sheaf of wheat. Actually, the two versions are only semi-visible, because of the last restoration.[4]

The palette is composed of black, charcoal, white (calcium carbonate), yellow and red (ochres), minium and green earth.[5]

The upper background (symbolizing the sky) is mostly composed of plain colours (white, red or green); this latter pigment is largely abraded today. The lower background (representing the earth) is composed of two large bands, one of which is striped and the other monochrome, with graceful flowers. For the lower registers this last band forms an arch motive (as in the tribune).

Chromatic changes affect certain parts. All depends on the pigments' alterations, both based on lead: white (biacca) and red (minium). Some are original, others are due to replacement.

Among the alterations

The paintings were frequently restored, both during the Gothic period, in the 15th century, and periodically throughout the 19th[6] and 20th centuries, until the last restoration (in the 1970s[7]). The discoveries made during that intervention or recently by our own studies reveal many of their different intentions (replacements, overlays, etc.) This is most apparent in the axial band, where different motifs have suffered from successive restorations.

My own project for future conservation treatments will carefully analyse every situation and extend the field of enquiry to the whole nave in order to clearly define the proper deontology and strategy.

The Crypt

Iconography

One descends to the crypt by two narrow stairways situated under the choir. Between the stairways lie three little windows. On the east-facing wall stands a larger window. All four probably served to provide light for the contemplation of relics, once conserved in the crypt.

The crypt is small (about 9 x 5 m) and barrel-vaulted. It is composed of two parts, a nave and a choir, which is slightly elevated.

All the surfaces are painted in the style of a manuscript. In the nave, they represent the legend of St Savin and St Cyprien, and, in the choir, Christ in majesty with the tetramorph, on the vault. Unrolled around Christ, the inscription reads: DAT SANCTIS DIGN[AS MIRABILI] SORTE CORONAS. [SIT CLAR]US INDEX MERITORUM SPENDIDUS INDEX ("He distributes crowns to the saints worthy of their wondrous fate. As magnificent guide, let Him be eminent judge of their merit").

On the walls, eight saints stand in arcades (Prudente, Fercincte, Savina, etc.); they are carrying crowns.

In the nave, the legend of St Savin and St Cyprien is related on the vault, commencing on the north, continuing on the south wall, and terminating on the west wall. The lower registers are painted with draperies.

The sequence should be read, from left to right, register after register, from top to bottom.

On the northern side:

- The two brothers, born in Brixia, exhort the idolatrous inhabitants of Amphipolis to adore the Lord. Note the contrast between the two groups, the saints being calm and the pagans agitated.
- The proconsul Ladicius, who had come to Amphipolis for a Dionysian feast, interrogates them.
- Punishment follows: tormentors with iron prongs lacerate their backs and slash Savin's arms.
- Having refused to worship idols, the saints are thrown in a furnace, but to no avail. They have Christ's protection.
- Fire touches and kills Ladicius and 160 co-citizens. The saints are led off to prison.

On the southern side:

- Maximus (Ladicius's colleague) receives them. Note the similarity between Savin and Cyprien's guards.
- Having refused the cult of Apollo, the saints endure a strange torture: their bodies are tied to the spokes of a wheel, and the wheel is rotated.
- The saints are then delivered to the lions, but the fierce animals lick their feet;

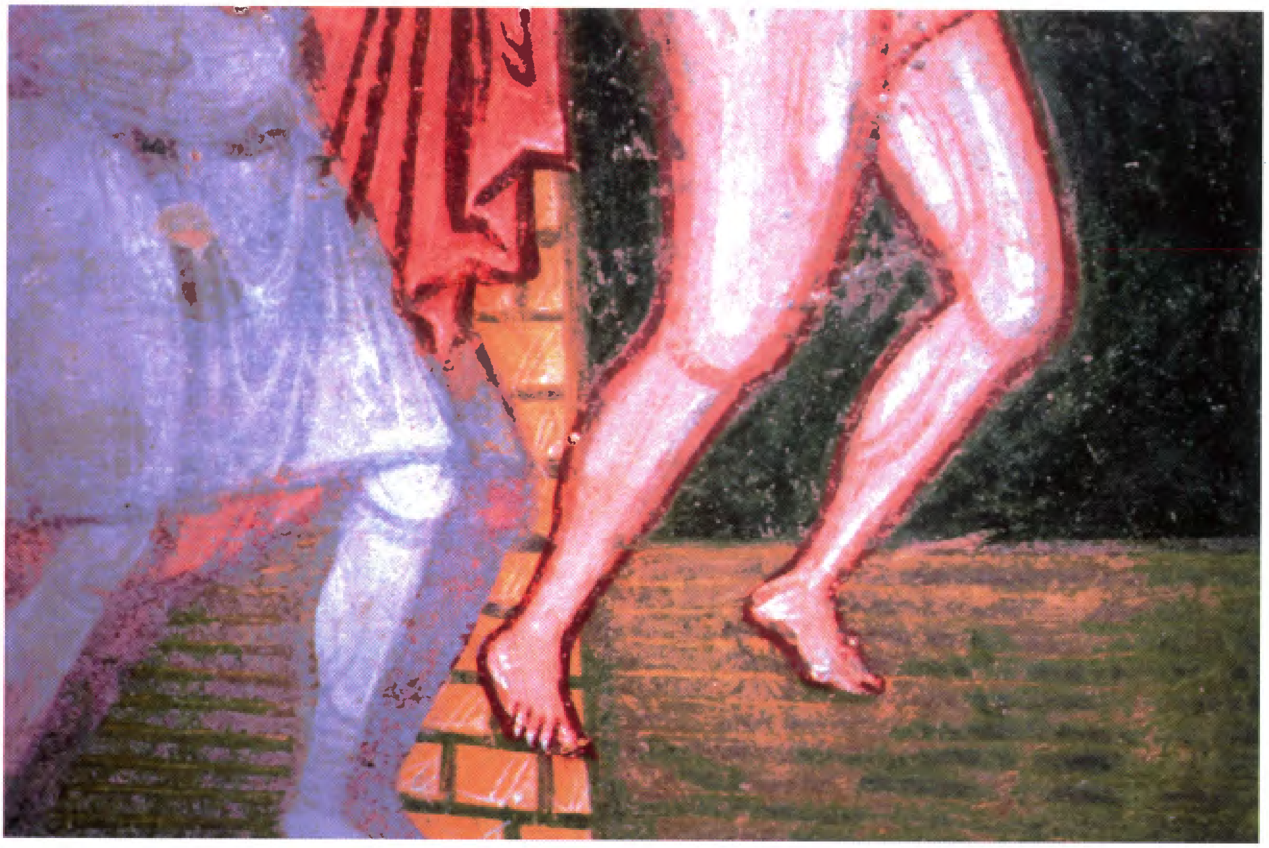

Figure 5. St Savin. The crypt. Laceration with prongs. Detail before (right) and after cleaning the white veil.

Figure 6. St Savin. The crypt. Legend of Sts Savin and Cyprien. Mid-part of the barrel vault, after 1995 restoration.

- In jail, the saints are freed by an angel who exhorts them to travel to Gaul.
- Maximus arrests the brothers near the river Gartempe. Savin cures and baptizes a madman and ten of Maximus's soldiers. The scene shows, at the same time, these very baptisms and Savin's decapitation, while God's hand is extended in blessing.

On the western side:

- The space is larger to show Cyprien's decapitation in Antigny (3 km from St Savin).[8]

Style

The crypt's painter is especially gifted in terms of ornament and narration. The style is concise, dense: the scenes follow one another without hiatus. The influence of illumination painting is manifest. Did the artist copy a certain manuşcript (for example, that of Saint Radegonde, Poitiers) or was he himself an illuminator?

The body's modelling is suggested by obvious volumes. The convex parts (pectorals, abdomen and knees) are treated in white, with round spots and concentric circles. Ribs and muscles are represented by slender white and red lines.

The robes are short and executed in a uniform colour, except at the neck and the hemline. Chlamydes – mantles worn by high personages – are knotted at the shoulders. Their length helps to determine chronology, as they lengthened after 1090.

The clothes fit the bodies tightly, but the fabrics tend to float. Draperies underline the various parts: abdomens in the form of an almond, breasts with concentric folds and groins with a 'V.'

The hands have luminous marks on their backs. Very expressively, they use stylized postures: one for conversation, one for blessing and one for designation.

The hair is separated by a parting in the middle, and often has a tuft. The proconsuls wear Phrygian caps.

The faces: principal features are painted green, the cheeks are strongly marked with red spots, while light underlines the forehead, the eyebrows, the undereyes, the bridge of the nose, the upper lip and, with two disks, the throat.

The architectural decor is rich and predominant. The artist has placed the saints' decapitation in an urban context, whereas legend places the event on the banks of the Gartempe.

The ornaments

Bands underline the architectural structure (eastern opening and arch) and registers. They are bicoloured (red and black) and adorned with white elements: mostly beads, cabochons and small horizontal traits.

Friezes are decorated in different ways. For example, one is composed of vegetable sheaves trimmed with ribbons alternating with disks. This same motif can be seen in Poitiers at St Hilaire and Notre Dame-La-Grande.

Marble imitations adorn the eastern part of the nave (both arch and steps), while in the stairways to the west they cover walls and ceiling.

The inscriptions

Texts complement the paintings, either as sentences displayed between registers, or vertically (in a smaller size), alongside persons in order to identify them.

Most letters are capitals, some are uncials. This can be used to date them to the late 11th to early 12th centuries. Later, the uncials predominate.

Technique

Apparently, the painter employed fresco at first, then secco.

In the nave, the intonaco is applied on a previous plaster. The pontate are around 3 m long and 1 m high (depending on the register). Plaster follows the contours of the depressions and is rarely smoothed. Joints are irregularly treated and often visible.

Some of the compositional axes are impressed in wet mortar (cords are used to delimit bands and horizontal lines) and fine indirect incisions serve to clarify certain facial elements or inscriptions. The preparatory drawing is freely traced with red ochre. It is visible in many parts where the paint layer is abraded.

The palette is composed of black, white, yellow and red ochres, employed pure or mixed. The green pigment is green earth, and the blue is lapis lazuli. It is used to decorate strips of sky and some dresses. These areas are now grey-blue, the underlying tone used as preparation for this precious colour.

The upper parts of the scenes stand out, either against green and blue, or uniform white. Their lower parts are covered with a similar earth band, striped yellow and green, but without the flowers found in the other cycles.

State of preservation and restoration

The crypt has just been restored. This implied monitoring the environment, applying extensive conservation treatments and realizing minimal pictorial reintegration. Only one of the many problems we encountered can be discussed here: that of the "white veil."

Environment

The L.R.M.H. monitored the environment over several years. The first approach dealt with capillary humidity, as the crypt is underground and close to the river. But studies and measurements indicated the need for further research. With the cooperation of the Hydrogeological Centre of the University of Bordeaux, a climatic, hydrogeological study was conducted. Various phenomena were revealed, such as water transfers from the saturated to the non-saturated areas of the subsoil. These transfers take place, whatever the season, in a "buffered" atmosphere in terms of temperature.[9]

The problem of "white veil"

At first, white veil was interpreted as salt efflorescence, increased by the action of products used in previous restorations. The veil was not uniform but had very distinct circular areas in which the painting remained clearly visible. The researchers thought at first that these areas corresponded to injections of consolidating agents.

A practitioner's diagnosis became necessary in order to study the condition both of the various paint layers and of supports, deposits and alterations. The analysis proved insufficient, due to the general presence of Paraloid and other compounds, and the difficulty of sampling the extremely thin layer.

Our approach has been as follows:

1- To set up a cartographic and photographic survey of the present state of conservation, over the whole surface. Visual examination (techniques of execution, surface deposits, alterations) has been clearly reported on graphics with specific symbols. This map has helped to understand this complex situation: diverse phenomena, the various causes of degradation and their interactions.

2- To clean an area in order to detect easily any evolution. The clean surface permitted good legibility and allowed us to start on a new basis. We began by eliminating the white veil mechanically gentle rubbing with soft brushes or erasers), then proceeded by removing excess fixatives in order to make the paint layer's appearance more uniform (point by point and with appropriate solvents).

Controls

One year later, the zone being monitored revealed new white formations, while other parts presented macroscopic phenomena with either granular deposits or fibrous efflorescence. This progression, from micro- to macroscopic phenomena, reveals clearly the veil's nature: it is microbiological, under the present optimal conditions for development.

Microbiological Study

A complete study was conducted by L.R.M.H in order to identify and quantify the micro-organisms and compare them with the conservation map to obtain some correlations between phenomena.

Classic procedures in microbiology (swab sampling, culture and incubation) established the presence of bacteria (especially actinomycetes) and fungi.

An antibiotic programme, specific to each colony, was implemented with the following products:

- Streptomycin – wide-spectrum bactericide
- Miconazole – wide-spectrum fungicide
- Echonazole – " "
- Nystatin – " "
- Fluorcytosin – " "
- Amphotericin – " "

Streptomycin sulphate and echonazole nitrate were the most successful.

In order to determine the causes and the eventual environmental contamination, other samples have been extracted from the floor and the ceiling (thanks to a trench dug in the choir), and from mortar cores. There was no unusual pollution, and the environment did not seem to play a special role in contamination.

Microbiological treatments

The surface of the entire crypt has been disinfected – floor, walls, stairways, windows – with great care given to microbiological milieu. Efflorescence was removed mechanically, by gentle rubbing with erasers, whenever suitable conservation conditions allowed. Disinfection was accomplished with biocides: streptomycin sulphate and echonazole nitrate diluted in benzyl alcohol and ethanol, applied with either brush or spray.

Efficiency reports

Controls were made and will continue to be made from time to time. Some months after the first treatment, the analysis showed excellent results in terms of the wall paintings while revealing a great deal of pollution on the ground (joints in paving stones).

Regular monitoring, after annual treatment, shows the presence of light contamination.

In conclusion, the problem and its resolution lie in the complementarity between scientist and practitioner (conservator-restorer). Also one must not underestimate the role of micro-organisms in decay of mural paintings.

Other conservation measures

Accurate examination, recorded in the form of five dossiers, provided a good knowledge of the paintings, their decay and the causes of alteration and allowed us to plan different treatments.

- Complete graphic mapping of conditions, including original techniques, alterations (supports and paint layer), deposits, past and "current" restorations.
- A complete set of detailed photographs, showing current conditions with the same data as for the graphic mapping.
- Report on each intervention.
- Periodic climatic surveys.
- Analyses: selected samples displaying techniques of execution and the phenomenology of alteration.

The conservation plan also included:

- Regular maintenance with biological treatments, specifically dosed.
- Cleaning: removing dirt, deposits and past restoration products.[10]
- Salt removal: nitrates, sulphates and carbonates.
- Spot reinforcement of the adhesion and cohesion, both of supports and of the paint layer.
- Filling lacunae in supports with appropriate lime/sand mortars, respecting granulometry, colour and texture.
- After cleaning, filling paving joints with lime mortar.
- Reintegrating missing paint with watercolours. Using *tratteggio*, when both possible and acceptable, on a finer and clearer mortar.

Once restoration has been completed.

- Regular maintenance with specifically dosed biological treatments will be carried out, if necessary. Until a more satisfactory situation can be found, the crypt will be closed to visitors or, more precisely, restricted to specialists.

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Notes

1. Historic Monuments Department. D.R.A.C. of Poitiers: Conservation -Restoration of the Crypt and the Porch, Study of the Tribune, the Nave with the scientific collaboration of the Laboratoire de recherches des monuments historiques (L.R.M.H.), Champs-sur-Marne; and the Choir with students from the Institut français de restauration des oeuvres d'art (IFROA) – Paris-St Denis, partly financed by the Centre international d'art mural (C.I.A.M.), St Savin).
2. See bibliography.
3. Note the size of the beads: fine for the 11th c, and double for the 15th c.
4. M.F. de Christen, in the 1970s.
5. Cooler green, copper ones, have been identified by recent analyses as overpaints.
6. Note date and signature from the last century: T. CUE, scene 2, or 1839, scene 5.
7. For the consideration of the vault, certain pictorial elements were detached and have not yet been put back.
8. In the last few years, IFROA's restorers, under my direction, have discovered and treated some very interesting paintings from the 14th c. They adorn, mostly with New Testament scenes, the walls of the church. See bibliography.
9. A special article has been published in the Proceedings of the IIC Bologna Congress, 1985. See biblography
10. Some fifteen superimposed materials have been found in some parts and judged damaging by nature

or in their proportions (clay, sulphate, highly hydraulic cements, etc., as supports and various repaints).

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THE TECHNIQUE OF MEDIEVAL WALL PAINTING IN CATALONIA, SPAIN

Rosa GASOL

ABSTRACT

The aim of this paper is to show a range of different examples of medieval Catalan wall paintings, especially from the Romanesque period, emphasising their pictorial technique and the particular character created by their geographical situation. This study, as a part of an ongoing PhD research project at the University of Barcelona on the subject, provides a review of data from the few publications available on Catalan wall painting techniques, and from the documentation on the conservation of the wall paintings.

Keywords: wall painting, technique, Romanesque, medieval, Catalan, Spanish, conservation, materials

Introduction

From the 9th century onward, after the Reconquest following the Muslim invasion, Catalonia was an independent territory called "Marca Hispanica." Later on, it developed as a series of independent counties, continuously extending their borders and fighting the Muslims. This gave them a strong internal cohesion, and led to an extensive campaign of religious building throughout the 10th-11th centuries. At the same time, relationships with monasteries in France and with the papacy in Rome, developed by the travels of nobility and abbots, paved the way for the arrival of a new artistic influence.

Art historians identify two main currents of stylistic influence on Catalan Romanesque painting: one Italo-Byzantine coming from Lombardy, and the other French. Others, however, have suggested that there is a Mozarab influence, from the Christians living in Moorish Spain.

Some 50 painted interiors exist; some are *in situ*, but the great majority are now in museums. This follows the campaigns undertaken during the 1920s, when a large number of wall paintings from various valleys in the Pyrenees were detached and transferred to new supports. This was done as a measure of protection as a result of cases of illegal dealing which led to some works being acquired by private art collectors.[1]

The painted schemes are generally not from large churches or cathedrals, which would have normally gone through various remodellings and redecorations and lost their original polychromy. They came instead from quite small churches, located in remote valleys in the Pyrenees. This gives them a strong local character.

Study of the painting techniques

With regard to painting techniques, we can speak of paintings started *a fresco*, with the typical preparatory layers, and finished with pigments mixed with lime or with an organic binding medium. The way that Catalan Romanesque wall paintings are described by the various authors is as a mixed technique or as *mezzo-fresco*.[2] This is relevant for the Romanesque wall paintings around the 11th-12th c. Later on and especially in the Gothic period, the pigments were increasingly bound with organic media, such as proteins or oil (Figures 1 and 2).

There are only a few published studies on examinations of Catalan wall painting techniques. These focus very much on the identification of materials, especially pigments, or on the description of the stratigraphy of the different layers.[3] It is hard to find complete studies analysing

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Figure 1. Apse in St Vicenc de Rus, Barcelona, 12th c. (Museu Diocesa i Comarcal de Solsona).

the original techniques of the painting. Information on other relevant features, such as the application of the plaster and its characteristics (e.g., types of joints) or the various methods of transferring to preparatory drawings, is hardly ever mentioned.

One of the reasons for this may be that these studies were mainly by art historians or scientists, rather than by conservators, with their broader and deeper knowledge of the subject, based on practical experience of painting technology.

Materials and their application

Support

The building materials used vary according to the location and the importance of the church. The small churches containing the majority of Romanesque wall paintings – those situated in the Pyrenees – are made of irregular blocks of local stone, including limestone, slate and granite.[4]

Plaster

The plaster can be composed of two or three layers, depending on the sophistication of the technique. Italian terminology is used to describe them. A first, coarse plaster is applied to level the masonry (*arriccio*), followed by a second, more smooth and compact layer (*intonaco*). Sometimes a third layer is applied on which the painting is done, either a rather thin coating (*intonachino*), or a limewash applied with a brush; this is the case in the early Gothic wall paintings of St Salvador de La Llacuna, in Barcelona.[5] The materials are usually lime, with sand as the aggregate, especially quartz, and the ratio varies from 1:3 to 1:1, depending on which layer is being applied.[6]

The way the plaster was applied, at least on the early paintings, is rather crude, showing an uneven surface. Tool marks can be observed in raking light, produced either by the final smoothing of the plaster, or as a way to retard setting and therefore, by drawing calcium hydroxide solution to the surface of the plaster, allowing the painter more time. This was the case in the archaic pre-Romanesque paintings of St Pere de Terrassa, where a small tool has left a pattern of parallel incisions across the plaster.

Figure 2. Angel musicians from St Pau de Casserres, Barcelona, 13th c. (Museu Diocesa i Comarcal de Solsona). Examples of the technique started a fresco and possibly finished with pigments mixed with lime or with an organic binding medium.

Figure 3. Fragmentary superposition of two decorations (10th and 11th c.). Detail showing the plaster joint, pick marks, and the preliminary drawing in red ochre, perfectly carbonated onto the plaster. "Crucifixion" from St Pere de Rodes (photo by R.Ramos-ARCOR).

As far as plaster joints are concerned, they follow the Byzantine system of large zones or pontate, rather than the later Italian *giornate*. A *giornata* has only been described from one scheme, in the Maiestas Domini in St Tomas de Fluvia, Girona, from the end of the 12th c. There is also a study on the wall paintings of La Cortinada, in Andorra, which suggests the presence of both types of plaster joints.[7]

A very clear example of a *pontata* can be seen just by visual examination of the feet of King Melchior in the upper register of the apse of Santa Maria d'Aneu (end of 11th c.) in the Museu Nacional d'Art de Catalunya, in Barcelona.

Transfer techniques

The preparatory techniques for the painting are mainly done by drawing a yellow or red ochre line as a separation for the registers and for the main compositional axis, sometimes by snapping a cord but mainly by free hand, directly on the final plaster. The very first stage of the painting technique can be detected from the preliminary drawing in red ochre, completely carbonated and consequently very well preserved, for the "Crucifixion" in the former monastery of St Pere de Rodes, Girona, from 10th and 11th c.[8] After the preliminary drawing, other pigments were applied using a binding medium, whether mixed with lime or with an organic medium, now almost completely disappeared (Figure 3).

Incisions have sometimes been found, especially in the haloes of the saints, possibly made with a compass and indicating that at the time the plaster was still fresh. *Sinopia* are infrequent, and there are no published references to them in the cases of the detachments carried out during the 1920s. However, in the recently detached painting of St Tomas de Fluvia mentioned above, a *sinopia* was found only in the apse, under the Maiestas Domini.

Paint layer

The technique a fresco was most frequently used in wall paintings in the Romanesque period, for the carbonation of pigments was the principal binding mechanism, at least in the first step of the painting, when the preparatory drawing and the initial blocking on of the colours were applied. The second stage would probably have required mixing the pigments with lime, or with an organic binding medium, in order to create the superposition of layers typical of this painting.[9]

Observation of cross-sections of wall paintings in the Museu Nacional d'Art de Catalunya, Barcelona, shows the pigment directly applied on the preparatory layer, and in some samples it appears to be mixed with lime that has carbonated later on, as in the scheme of Sta. Maria d'Aneu. In other samples, from St Joan de Boi in the same museum, the pigment has been mixed with a white clay (kaolinite), possibly in order to confer more plasticity and better cohesion with the painting.[10]

In the same study, the authors show the differences between the painters according to the way in which the layers are applied, the use of different materials, and the more or less careful grinding of the pigments. The best examples are the paintings of St Climent de Taull (*ca.*1123) and St Quirze de Pedret (end of 11th c.). Both schemes show a regular thickness of the painting layer and a uniform superposition of colours – ground tones, medium, highlights and outlines – that allow the master to obtain a great variety of tones using a very restricted palette.

As far as pigments are concerned, they are the ones suitable on an alkaline medium: lime white or St John's white, charcoal, and iron oxides. The blues have a specific significance, because of the widespread use in the Pyrenees of a local pigment, aerinite.[11] Other, more precious pigments, such as azurite and lapis lazuli, had to be imported. The blue was usually applied over a first layer of brown or black, for both technical and economic reasons. In the same way cinnabar, which was imported from Muslim Spain, was laid on top of the red haematites.[12]

Pigments found in Romanesque wall paintings in Catalonia and Andorra
(after Morer-Font,1993; Palet,1987,1992)

COLOUR	PIGMENT	PAINTING SCHEMES
White	Lime white (calcium)	Used in all schemes
Yellow	Goethite (iron oxide)	*idem*
Red	Haematites (iron oxide) Cinnabar	*idem* St Climent de Taüll
Blue	Aerinite Ultramarine (Lapis lazuli) Azurite	Masters of Taüll St Pere Seu d'Urgell Master of Pedret
Green	Mixed Aerinite + Goethite Glauconite (Green earth)	St Pere de Burgal St Quirze de Pedret
Black	Carbon (charcoal)	all schemes

Notes

(1) As is the case in Sta. Maria de Mur, now in the Boston Museum of Fine Arts. See: Pradell, J. 1982. Conservación y restauración de las pinturas murales de la iglesia de San Joan de Boi. *Actas del III Congreso de Conservación de Bienes Culturales,* Valladolid, Madrid: ICROA, (p. 69-72); and Ainaud de Lasarte, J. 1993. Les colleccions de pintura romanica del Museu Nacional d'Art de Catalunya. *Butlleti MNAC,* I,1, Barcelona (p.57-69).

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(3) Palet, A., & de Andres, J. 1992. The identification of Aerinite as a blue pigment in the Romanesque frescoes of the Pyrenean region. *Studies in Conservation,* 37 (132-136); Morer *et al.,* 1980. Estudio tecnico y mineralogico de las pinturas del Palacio Berenguer de Aguilar. *Actas del III Congreso de Conservacion de Bienes Culturales,* Valladolid. Madrid: ICROA, (p.53-67); Morer, A., & Font-Altaba, M. 1993. Materials pictorics medievals. Investigacio de les pintures murals romaniques a Catalunya. *Butlleti MNAC* (Barcelona), I,1: 71-115.

(4) Baglioni, R., Planas, M., & Palet, A. 1988. *Restauración de La Cortinada, I fase,* Conselleria d'Educacio i Cultura, Andorra (unpublished report).

(5) Direct observations during the conservation treatment, as published in "Proces de conservacio y restauracio d'un fragment de pintura mural a La LLacuna," in *Memoria de les Intervencions en el Patrimoni Arquitectonic,* Diputacio de Barcelona 1990.

(6) Baglioni-Palet-Planas, 1988 *(op. cit.)*

(7) Xarrie, J.M. 1988. Les pintures murals de Sant Tomas de Fluvia. Proces de conservacio i restauracio. *De Museus. Quaderns de Museologia i Museografia,* 1, Dept. Cultura Generalitat de Catalunya, Barcelona (p.116); Baglioni-Palet-Planas, 1988 *(op. cit.).*

(8) Information collected during the conservation work carried out jointly with ARCOR, Barcelona, in 1995.

(9) Pradell, J. 1983. Intervencio a les pintures de Sant Vicenc de Rus, Barcelona. *Memoria del Servei de Patrimoni Arquitectonic,* Diputacio de Barcelona.

(10) Morer-Font, 1993 *(op. cit.)*

(11) Palet. 1987. Aerinite, pigment bleu de la peinture murale romanique des Pyrenees. ICOM Meeting, Champs-sur-Marne; and Palet, 1992 *(op. cit.).*

(12) Morer-Font, 1993 *(op. cit.).*

WALL PAINTINGS: SIMPLE INVESTIGATIONS

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Introduction

This article describes the approach to the treatment of the wall paintings situated in the crypt of St Maria im Kapitol in Cologne, Germany. The paintings are in a disastrous condition; the aim was to find a consolidating method which allowed a combination of both consolidation and desalination.

The wall paintings of the crypt of St Maria im Kapitol

The church of St Maria im Kapitol, is regarded as one of the most famous Romanesque fabrics of the 11th century. The church consists of a main hall with three naves, the eastern choir is constructed as the apse of a triconch. Two towers flank the church in the west. The church was consecrated in 1065.

The crypt of the church is situated under the triconch. It consists of a hall with three naves and five side chapels. All these chapels bear the remnants of mural paintings from the Romanesque and Gothic periods.

Historical highlights (after M. Feld 1991):

1st century (A.D.): Roman temple

7th century (A.D.): Foundation of a convent for aristocratic ladies and erection of a church under Plectrudis

10th century: New church under archbishop Bruno

1015: Construction of the church under abbess Ida

1065: Consecration of the church

1802: End of the convent

1838-1851: Crypt used for salt storage

1854-1898: Renovation and decoration of the church in a style influenced by historicism

1900: Mural paintings in the crypt documented in watercolours

1942/1945: Church destroyed during the Second World War

1950: Church reconstructed

1952: Crypt used for services

1957: Church reconsecrated

1960-1970: Crypt: floor heating installed, mural paintings consolidated with sodium silicate by Reibold.

Foundations consolidated with injections of concrete

1976: Crypt replastered

1978: Mural paintings consolidated with Mowilith DM 55

1987: New air heating system installed.

The painting in side chapel B

The work presented here focuses on a painting in the vault of the north-eastern side chapel of the crypt. A watercolour by Schoof documents the state of the Romanesque painting in 1900 (Figure 1).

The main scene shows the Last Supper, surrounded by an inscription. The text of the inscription is: *Beati qui ad coenam agni vocati sund* (Rev 19:9). In the beginning of this century, when the painting was much more legible, it was dated to the middle of the 12th century (*ca.* 1160) by Clemen.

In its current state, the painting is virtually illegible.

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The painting technique

The painting is executed on a brownish lime render with a thick whitewash layer on top.

The render contains fine quartz sand as aggregate but also particles of calcium carbonate as well as clayey and volcanic particles. Analysis of the whitewash layer showed that it contained such a high amount of gypsum that it must have been added originally. The original brown render exists only in the painted parts.

The painting itself is partially overpainted or retouched. For example, the blue background of the painted arcades was originally painted green. Incisions were used to divide the painting. They were executed with compasses, as for the construction of the nimbus.

Actual condition of the painting

The condition of the original paintings and their supporting renders is very poor, so that the slightest touch could cause the loss of more original material. The painting has become illegible because of a treatment with water glass which has altered to grey. This treatment was carried out in the sixties and resulted in a rigid and dense layer on the surface of the painting, thus preventing water evaporation.

Other damage, such as drippings of Mowilith DM 55, is the result of an unconsidered use of synthetic resins during the last restoration in 1978. Blue retouchings on an earlier repair render prove that the painting had already been retouched before 1900.

Causes of damage

The crypt suffers from very serious salt problems, for a variety of reasons: its walls are penetrated by ground moisture; it was used as a salt store in the 19th century; the vaults were repaired using concrete during the Second World War; the whole church was seriously damaged by bombs and consequently exposed to weather for several years. Finally, during the 1960s, the wall paintings were treated with water glass. Cyclic crystallization of salts on the walls as described by Laue (in press) was the result of this history of devastation. Although salt efflorescence had never been found on the painting itself, analyses proved the existence of salts in the plaster

Long-term monitoring

In order to obtain more information about the behaviour of the supposed salt content, it was decided to monitor the painting for a longer period.

The climate was measured with thermohygrographs, together with measurements of the surface temperature and the moisture content of the walls.

Flaking

After a year of monitoring, it could be seen that it was only during wintertime (when the crypt is very dry) that a certain amount of tiny paint losses (flaking) occurred, as they could be found lying on the scaffolding. In contrast, very few losses occurred in the summertime, under moist conditions. The flakes consisted of particles of the render and paint layer (sand, calcium carbonate, etc.) and seemed to be a sort of indicator of the intensity of damaging mechanisms.[1] In order to use the amount of flaking to measure this intensity, the scaffolding platform was divided into several fields. The falling material was collected regularly for more than two years and gravimetrically measured.

The amount of flaking obviously increased when the relative humidity (RH) fell below 60% for longer than two weeks.

Conclusions from the results of investigations

Climate measurements in the crypt showed major changes in RH between winter (sometimes down to 30%) and summer (frequently *ca.* 80%). These changes are produced artificially by winter heating of the crypt.

In the painted vault, the quantity of losses of surface material – which was collected and weighed regularly – correlated perfectly with the room climate and the cyclic salt crystallization on the lower parts of the walls, where crystallization occurs only during dry winter periods.

Other measurements of the surface temperature proved that the temperature never falls below dew point.

By this it could be shown that hygroscopic salts are mainly responsible for the degradation of the wall paintings. The salts crystallize during dry periods (winter) and they dissolve under moist conditions (summer).

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[1] The principle of such measurement had been already applied by W. Franz (1991) in Hemmerich and by F. Mairinger in Lambach.

Figure 1. Watercolour by Schoof, documenting the state of the Romanesque painting in 1900.

Other damaging factors such as micro-organisms and rising damp in the walls are comparatively insignificant as mechanisms of degradation.

The measurements clearly show that RH below 60% causes stress to the painting. Obviously, the current climatic situation in the crypt is not ideal.

Conservation planning and choice of materials

The mural painting is in such a disastrous condition that it is nearly impossible to touch it. This means that the first treatment had to be consolidation, followed by desalination to reduce the salt content of the surface materials.

The only promising method for desalinating these wall paintings and their supporting renders seemed to be to apply compresses once the surface was consolidated.

The only example of wall paintings that were treated in a similar way was published by Hammer (1987/88). Therefore it was necessary to test the consolidants in the laboratory before applying them to the original wall paintings.

All investigations on the wall paintings in St Maria im Kapitol led to the formulation of the following list of requirements for the consolidant and its method of application, namely that it should:

- easily penetrate the mortar's porous structure;
- not alter the paintings' appearance;
- not seal the surface against water vapour;
- not be hydrophobic after treatment;
- not affect a desalination after the consolidation;
- not be easily affected by micro-organisms; and
- have a consolidating effect that is not strongly influenced by salts.

The application method for the consolidant should cause as little physical stress to the painting's surface as possible.

Silicic acid esters (SAE), which have been used for some decades as stone consolidants, seemed to fulfil the majority of the requirements listed above. However, very little is known about the behaviour of SAE in structures that are contaminated by salts.

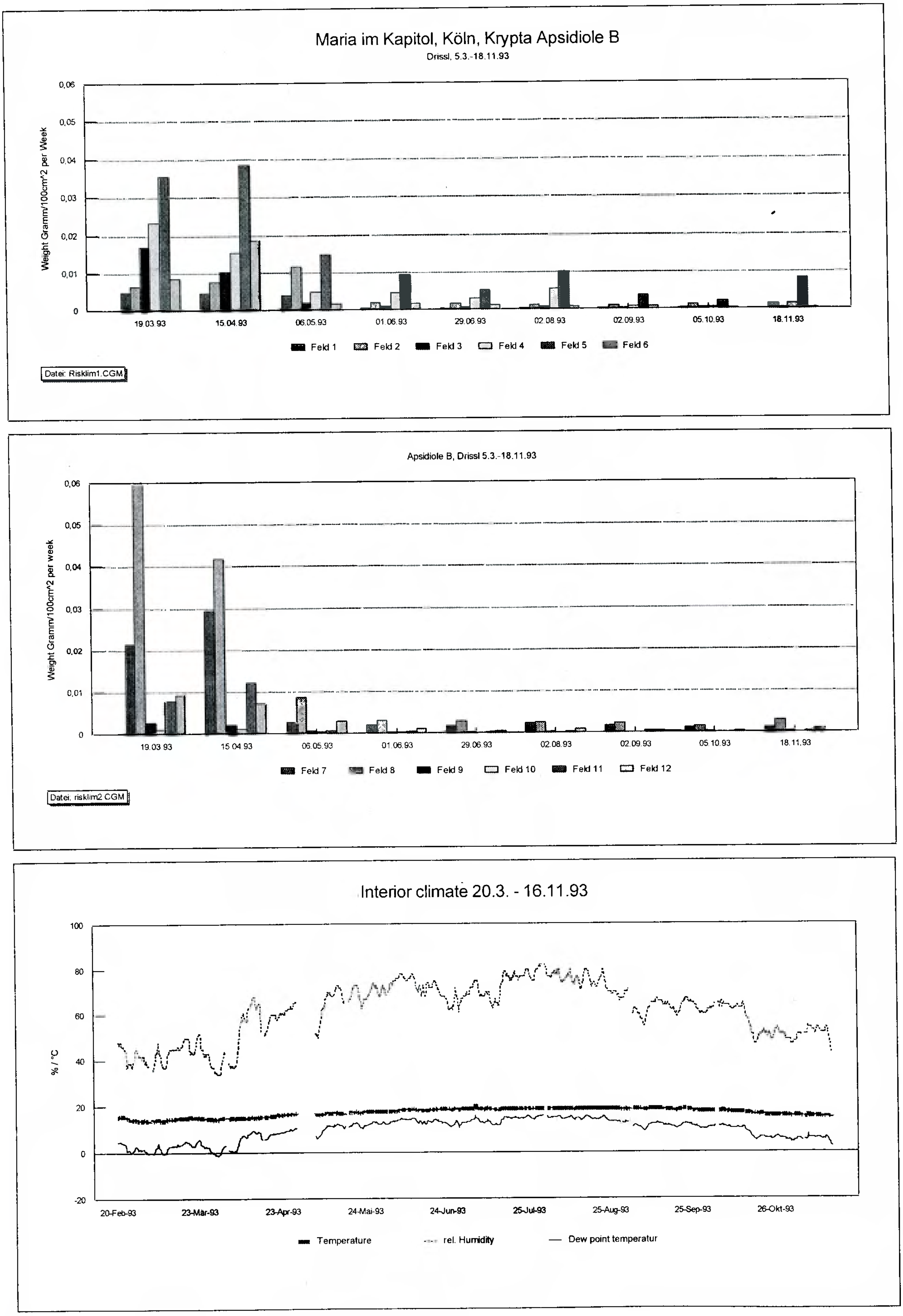

Figure 2. Flaking from 5 March 1993 to 18 November 1993.

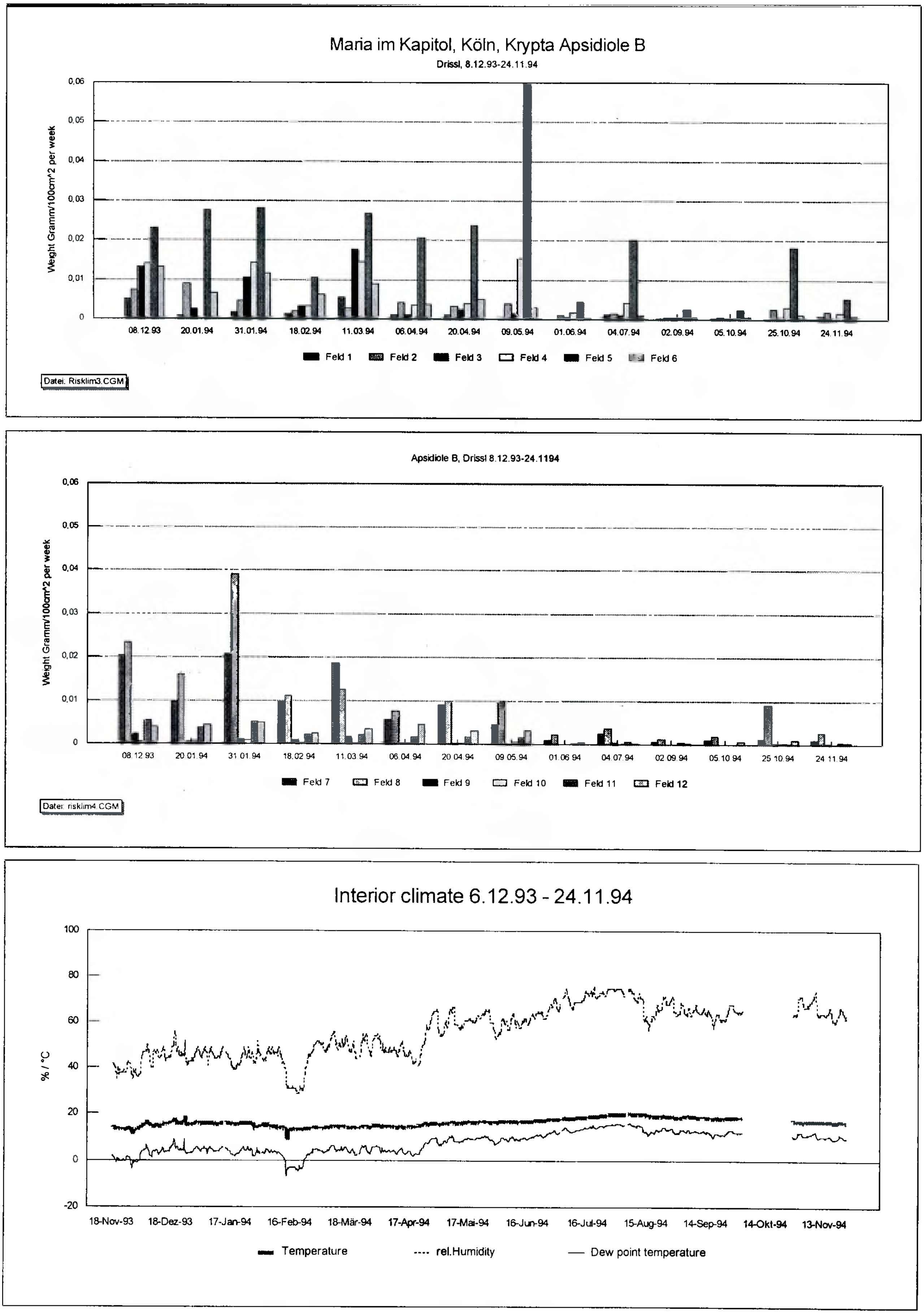

Figure 3. Flaking from 8 December 1993 to 24 November 1994.

Table 1. Salt analysis

	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	NO_3^-	SO_4^{--}	IB	IS
A	64	17	127	33	107	185	42	25	27 301
B	70	20	121	36	109	201	46	0	28 848
C	65	<20	176	42	127	207	32	102	30 032
D	176	49	273	95	323	506	29	73	64 820

Key: A = Average salt content measured in the original mortars; **B** = salt mixture added to the laboratory samples of the 5% group (calculated values); **C** = amount of salt actually measured by water extraction in the laboratory samples of the 5% group; **D** = salts measured in the 10% group. (IB = ionic balance; IS = sum of measured ions.) All values in mmol/g of sample] except for IS, which is given in mg/g of sample].

The scarce literature about this problem offers somewhat contradictory information: Sattler (1992) claims that salts strongly affect the hardening of SAE, whereas from the restoration of ceramic archaeological objects, it is known that the use of SAE does not hinder later desalination (Sander-Conwell, 1995), which implies that SAE must have had a consolidating effect despite the presence of salts. Grassegger (1990) notes that SAE gels formed under the presence of salts have a higher content of adsorbed water and show less silanol content than salt-free gels, which might have a diminishing effect on the stability of the gels.

To better understand the reactions that might occur between silicic acid ethyl esters and salts, we mixed, in a preliminary test, various commonly used SAE products with salt mixtures (sodium nitrate, sodium chloride and gypsum), with salt-free and salt-contaminated lime mortar particles and with salt-contaminated particles that had fallen off the wall paintings at St Maria im Kapitol. The hardening of these samples was observed and the products compared by estimating their speed of reaction, their influence on the sample colour and their tendency to crack. It could be seen that the time needed for consolidating became much longer in the presence of salt compared to salt-free samples. From these experiments, three silicic acid ethyl esters were selected to undergo an extended laboratory test: Funcosil-OH (does not induce water-repellancy); Funcosil 300 (a solvent-free SAE); and Motema 28 (an uncatalysed SAE), used in a 5:1 mixture (by volume) with Funcosil OH. All three consolidants are frequently used by restorers in Germany.

Laboratory tests for consolidants and desalting

The laboratory samples should match as perfectly as possible the state and the salt content of the plasters on site, because the main aim of the work was to find out which consolidant best met the requirements at St Maria im Kapitol, as mentioned above.

In order to get clear results regarding the hardening effect of the consolidant, it was decided to use a loose mixture of sand and calcite ($CaCO_3$). The quartz sand was sieved to have the same

Sample number	Salt content	Consolidant
1b	none	Funcosil-OH
3a	5.00	none
3b	10.00	none
4a	5.00	Funcosil-OH
4b	10.00	Funcosil-OH
5a	5.00	Funcosil 300
5b	10.00	Funcosil 300
6a	5.00	Montema 28 : Funcosil-OH (5:1 by volume)
6b	10.00	Montema 28 : Funcosil-OH (5:1 by volume)

Table 2: List of laboratory samples, with their salt content and type of consolidant.

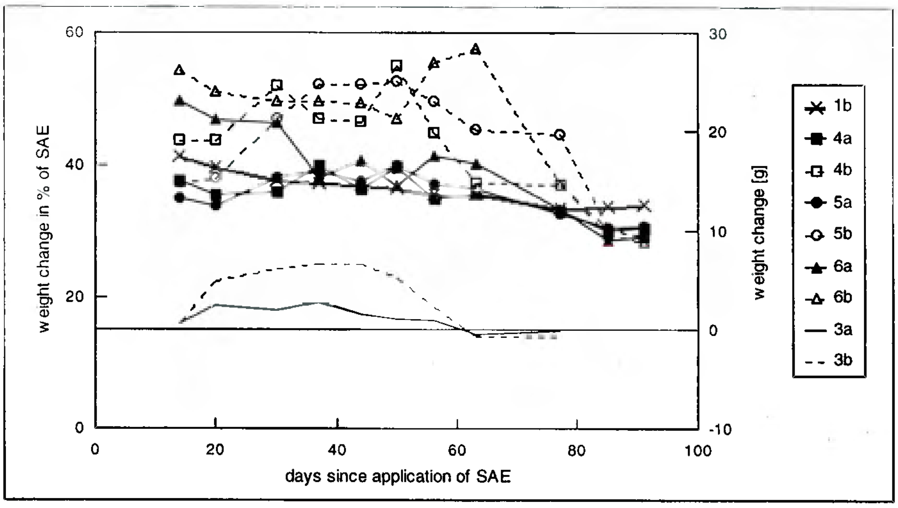

Figure 4. Weight change in % of SAE during the hardening reaction of the consolidant, and absolute weight change in g of the two samples 3a and 3b, containing no SAE.

grain-size distribution as the original mortars, and care was taken to keep the ratio of sand to calcite the same as in the original.

The salt mixture was calculated from an average of twelve samples, all taken in the vault which was to be treated (A in Table 1). Gypsum was added to the samples as a powder. The other salts were added as a solution. The final mixtures were then thoroughly mixed and filled about 2 cm deep into rectangular glass basins (16 x 8 cm) and left to dry to constant mass in a climate of about 50-70% RH and 23°C.

The samples contained about 3% of water-free salt (IS in Table 1). From weight loss after the water extraction we know, however, that this corresponds to about 5% total salt content (not counting water of crystallization of the salts), therefore this group of samples will henceforth be called the 5% group. A second group of samples was prepared analogously to contain about 10% salts (D in Table 1), to see what effect an even greater salt content would have on the consolidants and the possibility of desalting. One salt-free sample was prepared as a control. The complete list of samples with their amount of salt and type of consolidant is given in Table 2.

The consolidation of the original wall paintings with SAE was done by capillary imbibition (see consolidation, below). This method, however, was not applicable to our laboratory samples, which consisted of loose sand and hence could only be treated from above. Therefore we calculated the amount of SAE which was necessary to wet the sample material to an extent similar to the imbibition method, and poured sufficient volume (1.2 g of SAE per 10 g sand) on the samples. In order to have a homogeneous distribution of SAE, the material was stirred thoroughly and afterwards the surface was flattened without executing pressure, to avoid any sedimentation or segregation of material.

Results

Observation during curing of the samples

After the addition of the SAE, the samples were left to cure in a climate of about 50-70% RH and 23°C. For over three months, they were regularly examined for alterations in colour, hydrophobic behaviour, smell, hardness and weight change.

Colour: Some SAEs change the colour of a treated surface. Both Funcosil 300 and the mixture of Motema 28 + Funcosil OH resulted in hardly any colour change of the samples, when compared to untreated samples.

Weight change: During the hardening reaction, SAE loses weight because the solvents and/or parts of the SAE evaporate. The weight change thus gives an indication of the amount of reacted SAE that remains in the material, and this gives an indication of the reaction time of the SAE (Figure 4). For several reasons, however, the samples were not kept in a completely constant climate during curing, so that the presence of hygroscopic salts also resulted in weight changes (curves 3a and 3b in Figure 4).

From Figure 4 it can be seen that the samples containing 10% salt changed their weight much more irregularly than the samples containing 5% salt. Furthermore, it can be seen that the samples consolidated with the Motema 28 + Funcosil-OH mixture (6a and 6b) reduced their weight less

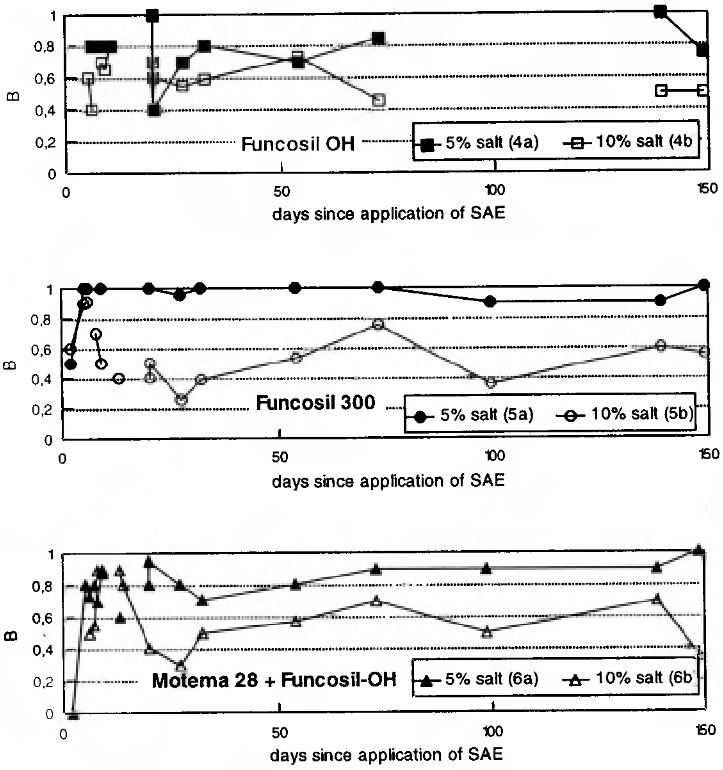

Figure 5. B value from the "needle test" plotted against the days since application of the consolidants.

continuously than samples treated with the other two products.

Hardness: The hardness was measured by what we called the "needle test." A needle weighing about 5 g was dropped from a distance of 5 cm onto the surface of the sample. As long as the sample is still soft, the needle will penetrate and stick, whereas on a hard surface the needle will bounce off. In each trial, this was repeated about ten times, and the number of times the needle either stuck or bounced off was counted. The number of bounces divided by the number of repetitions was calculated and called 'B.' If B equals one, this means that the needle always bounced off and, therefore, that the sample was hard. A low 'B' value meant that the sample was (still) soft.

In this needle test, all samples containing 10% salt (curves with open symbols in Figure 5) remained rather soft. Funcosil 300 showed the best performance regarding hardness, which can be seen by its B value remaining close to 1 after only a few days of curing time.

Salt analyses of desalting compresses of the laboratory samples

After curing the samples for more than three

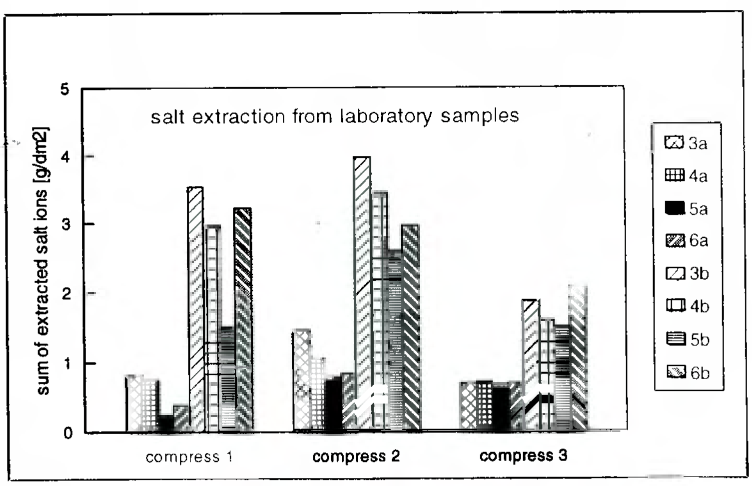

Figure 6. Total amount of ions extracted from the laboratory samples. Sample 1b is not plotted because its salt-ion content was too low (0.006 to 0.008 g/dm²).

months, desalting compresses of Arbocel BC 1000 with deionized water were applied to them. Each of the three compresses was left on for 24 hours and then replaced by the next compress.

From the salt analyses of the compresses, it could be seen that the ions were extracted in about the same relative proportion as they were contained in the samples, i.e., no ion was significantly better extracted than another.

One rather amazing fact was that the second compress in all cases (even in the samples containing no SAE) led to the extraction of more salts than the first compress (Figure 3); this is in contrast to other experiences with similar compresses (see, e.g., Grüner & Grassegger, 1993), and we do not have a final explanation for this. We suppose that it has something to do with the fact that our samples were placed in glass containers and not on porous systems.

The smallest amount of salts was extracted from the samples treated with Funcosil 300, which was the consolidant that gave best results regarding consolidation. The total amount of extracted salts lay between 200 mg and 1 100 mg per dm^2 of surface area of the consolidated samples containing 5% salt (for full analyses see Table 3 in the appendix).

Conclusions from the laboratory experiments

Funcosil 300 was finally chosen as the consolidant for the test area at St Maria im Kapitol because – after the three compresses – the surface of sample 5a appeared to be in better condition than the surfaces of any of the other samples. Another reason for its selection was the fast and durable hardening of this consolidant (Figure 5). Although the salt extraction was more reduced by Funcosil 300 than by the other SAE, it was decided that the consolidation effect on the renders and wall paintings was the most important criterion for the selection of the consolidant, as desalination always means some physical stress to the treated material.

In situ tests in St Maria im Kapitol

Consolidation

Common application methods for consolidants, such as spraying, using a paintbrush or compresses, were considered to be too abrasive in this case, where the paintings could only be touched at a few spots. The application method was therefore specially developed. Analogous to the Mirowsky testing tubes for the measurement of liquid penetration into porous materials, we used glass tubes with a

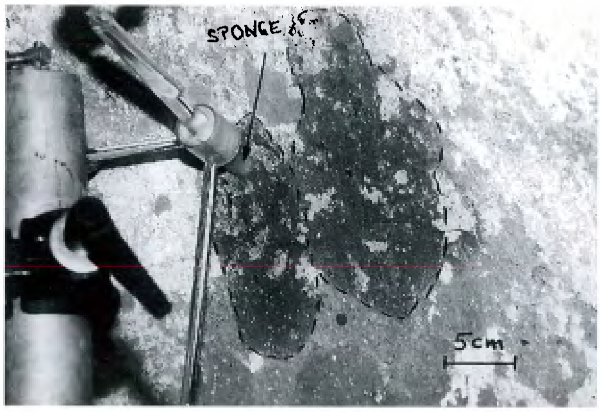

Figure 7. Apparatus to apply the consolidant. The dashed lines mark the dark areas where the consolidant is being applied or was recently applied.

sponge, which served as contact point with the wall. The other end of the tube was connected by a flexible silicon tube to a container with the SAE supply. The consolidant was then sucked up through the sponge by the materials of the wall, mainly due to capillary forces. The advantage of this method was that with only a few contact points of about 1 cm^2, it permitted impregnation of oval areas of nearly 1 dm^2 near the sponge (Figure 7).

This time-consuming method, which is normally uneconomical, was used in order to have

Figure 8. Compresses with their mechanical supports at the test area in St Maria im Kapitol.

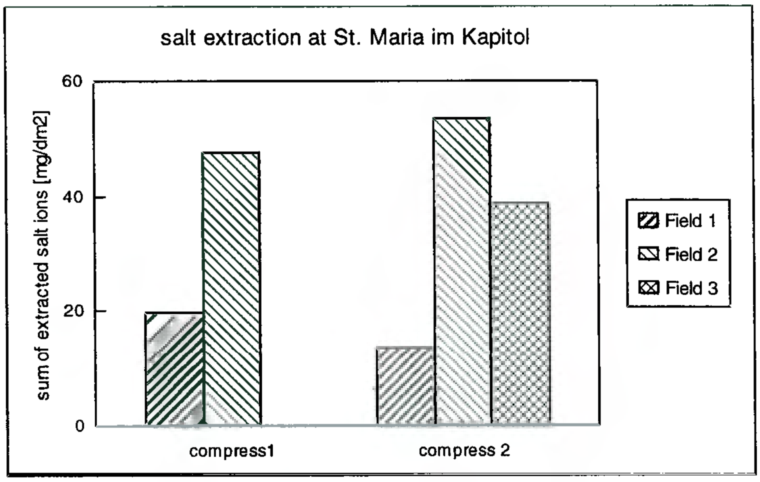

Figure 9. Total amount of extracted salt ions from in situ desalination.

as few contact points as possible on the fragile surface of the painting. The method is very complicated, as its success depends on the suction power of the material: it took 7 days to apply 1.5 litres of Funcosil 300 to an area of about 0.5 m^2.

Two months after the treatment, the surface of the testing area resisted much better to the prick of a needle than the untreated parts. The test field did not show alterations, with the exception that it appeared slightly darker than the surrounding parts. When a few water drops were applied to the render, they were immediately sucked away. By using this application method for the consolidant, even strongly damaged parts of the painting, like loose hanging parts of the paint layer, could be saved.

Some parts, however, were still in danger of being lost during desalination, and they had to be fixed by a SAE to which some ammonia was added to enhance the reaction speed.

Desalination

The desalination was carried out as for the laboratory tests by using cellulose compresses with deionized water. Arbocel BC 1000 – a product frequently used for these purposes – was employed. Following the laboratory tests, Arbocel at 18 g per dm^2 was calculated to be necessary. Four consecutive compresses were applied. The first was left on the wall for three days, and the following ones were each left on the wall for 24 hours. Because of the spherically inclined vaulting, the compresses had to be supported by flexible polyurethane plates, covered by plastic sheets (Figure 8).

The compresses did not dry out on the wall, so that they were still quite humid when they were taken away, with the lower parts having a remarkably higher water content than the upper ones. Because of the supports, the compresses could be removed in big plates without breaking apart. This helped us to control whether particles from the paintings were being removed together with the compresses. With this method we could be sure that only a very little material was accidentally removed from the paintings.

Results of sample analyses

Given time constraints, only some of the compress material could be analysed. Therefore, the first two compresses from the two lower fields and the second compress of the third field were selected for analysis. As the lower fields had been much wetter when the compresses were removed, these compresses were expected to contain more salt than the compresses of field 2 or 3; this, however did not turn out to be true (see Figure 9 and Table 4 in the appendix).

The compresses led to the extraction of between 13 mg and 54 mg salt per dm^2 of surface from the wall paintings, which is up to 20 times less than what was extracted in the laboratory tests. This probably has to do with the fact that the material lying underneath the original renders is porous and could therefore suck away some of the applied water, and lead to a redistribution of the salts rather than to an extraction.

Conclusions

It could be shown that different silicic acid ethyl esters could strongly influence the possibility of desalination, and that the consolidants themselves were also strongly influenced in their consolidating effect by the presence of salts.

To further test the possibilities of desalination of renders after the application of consolidants, it would be necessary to set up different laboratory tests, or to find an ancient render where adequate test fields could be set up.

It should be underlined that even simple measurements like the 'flake count' method offer reliable results when the investigation is adapted to the specific conditions of the object.

This was possible because we not only measured the conditions of a room, but also we had the chance to measure both the intensity of damaging alterations and the circumstantial conditions which affect the monitored alterations on the painting – thus giving an idea of an ideal diagnostic method consisting of a series of combined observations, which should provide a complete picture of causes and effects for the individual monument.

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Acknowledgements

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This work was supported by BMFT Germany. We would like to thank K.L. Dasser and the other co-workers in the BMFT Project *Erhaltung historischer Wandmalereien*. We thank especially Margret Hirsch for sample preparations and salt analyses. To Elisabeth Jägers and Steffen Laue, we are grateful for many fruitful discussions.

Appendix

Suppliers

Motema 28. Interacryl, Schultheissenweg 105 c, D-60489, Frankfurt/Main, Germany.

Funcosil OH and **Funcosil 300**. Remmers Chemie GmbH&Co, P.O.Box 1255, D-49624 Löningen, Germany.

Arbocel BC 1000. J.Rettenmaier & Söhne GmbH+CO, D-7092 Holzmühle über Ellwangen/ Jagst, Germany.

Sample	Na^+	K^+	Ca^{++}	Mg^{++}	NH_4^+	Cl^-	NO_3^-	SO_4^{--}	Sum
1b/1	1 639	<2 200	2 145	283	6	3 781	354	<11 000	8 208
1b/2	1 247	<2 200	1 893	224	5	2 211	452	<11 000	6 032
1b/3	1 387	<2 200	2 077	314	18	1 520	532	<11 000	5 849
3a/1	70 851	43 620	96 798	20 329	29	166 540	374 652	20 980	793 799
3a/2	116 044	59 571	183 487	48 079	80	274 088	734 555	29 205	1 445 110
3a/3	53 795	30 366	94 301	18 564	56	125 211	343 966	15 112	681 371
4a/1	55 056	29 875	99 172	18 799	27	145 175	358 816	17 675	724 594
4a/2	73 324	31 970	161 368	27 848	14	191 361	521 320	33 268	1 040 474
4a/3	49 135	23 968	107 096	20 121	54	125 982	359 005	22 133	707 492
5a/1	17 759	8 941	33 086	5 440	14	47 676	108 499	<11 000	221 415
5a/2	65 798	38 254	111 948	14 002	25	152 962	363 553	26 630	773 171
5a/3	47 027	24 492	99 684	19 023	44	119 339	341 996	17 079	668 684
6a/1	30 638	20 296	55 843	5 022	14	76 843	169 321	17 837	375 814
6a/2	71 199	41 856	117 356	12 607	14	161 910	385 289	27 859	818 092
6a/3	49 664	26 598	103 199	19 865	42	127 633	350 606	13 441	691 048
3b/1	340 721	128 728	416 128	115 788	73	813 983	1 689 939	29 043	3 534 402
3b/2	318 864	155 633	512 611	145 989	50	785 277	2 020 797	32 947	3 972 167
3b/3	134 872	77 593	255 581	60 646	86	338 625	992 064	16 271	1 875 738
4b/1	272 772	113 659	416 196	68 662	77	645 146	1 420 000	29 872	2 966 384
4b/2	274 280	127 013	496 097	93 262	29	675 068	1 742 372	37 280	3 445 400
4b/3	111 155	66 370	223 186	47 168	80	282 690	836 770	17 421	1 584 842
5b/1	152 893	73 629	232 367	36 597	23	195 811	787 160	22 236	1 500 716
5b/2	222 989	105 473	370 984	59 832	63	544 709	1 253 498	33 666	2 591 214
5b/3	114 039	63 806	209 134	42 525	61	284 805	778 692	13 277	1 506 340
6b/1	287 047	125 333	452 122	76 402	81	694 648	1 545 190	33 977	3 214 800
6b/2	239 336	114 818	426 069	70 718	50	598 941	1 466 167	35 299	2 951 399
6b/3	137 832	79 237	268 172	60 155	56	353 982	1 165 153	19 059	2 083 647

Table 3. Analyses of the compresses of the laboratory samples. All values are given in µg/dm². The number following the sample number indicates the number of the compress.

Compress no.	Field no.	Na^+	K^+	Ca^{++}	Mg^{++}	NH_4^+	Cl^-	NO_3^-	SO_4^{--}	Sum
1	1	<270	3 950	439	6 999	403	164	7 910	<11 000	19 866
2	1	2 383	<2 200	1 700	294	17	3 476	5 693	<11 000	13 564
1	2	<270	8 976	2 926	16 209	131	331	18 951	<11 000	47 525
2	2	4 457	<2 200	8 455	880	385	8 897	28 561	<11 000	51 635
2	3	3 611	<2 200	6 125	771	171	7 128	20 502	<11 000	38 308
	blank	561	<2 200	<540	<140	2	480	105	<11 000	1 148

Table 4. Analyses of the compresses that had been applied in situ. All values are given in µg/dm². (The very high ammonia contents are due to the use of ammonia during consolidation.)

PRESERVATION OF WALL PAINTINGS AND OTHER ARCHITECTURAL SURFACES AFFECTED BY SALTS

Interdisciplinary remarks on interpretation of the physical system and the damage processes

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Bundesdenkmalamt, Abteilung für Konservierung, Vienna

ABSTRACT

Interventions on mural paintings and other architectural surfaces often increase damage if they focus on symptoms alone. The interventions have to be linked to a structural understanding of the physical system and its preservation. To evaluate damage factors, a distinction has to be made between normal alteration processes – i.e., ageing – and dramatic decay caused by exceptional factors. The remarks reflect the interdisciplinary point of view of a conservator-restorer. At the end, practical methods of how to treat damaging salts are listed, with some comments.

Introduction: Learning from history

Historic monuments are not only the material evidence of ideas implicit in cultural and artistic heritage. They also represent technical experience and knowledge developed over thousands of years. Their very existence is historic proof of the intelligence of technical solutions, not only of the original components, but also of later interventions, e.g., maintenance and repair. Modern interventions, based on interdisciplinary scientific and empirical research and knowledge, should take this historic experience as a lesson and as a starting point.

Indeed, the plastered surfaces of historic monuments reveal an astonishing resistance to normal weathering. The parish church of Weissenkirchen in Wachau (Austria) may be a meaningful example (Figure 1). The original rendering of the main tower, dating from 1502, is still preserved. This cannot be explained only by the fact that it has been maintained at reasonably regular intervals or by the favourable climatic conditions of the region. The surface texture of the rendering is rough, so water can easily infiltrate. According to the ruling theory, water is the main enemy of a building. That theory cannot explain the preservation of the historic rendering up to our times.

Interpretation of the normal physical function of a porous rendered surface

In the case of the original rendering of Weissenkirchen, we can see that the facade is well protected by several cornices. Where the protection system provided by the architect does not work, the rendering is quickly damaged

In order to understand and interpret the rendering as a physical system – as an interface between structure and environment – we need scientific methods as well as phenomenological and empirical methods. We have to take into account that this system is more than the sum of its parts. Its normal reaction against weathering factors has to be characterized and interpreted with interdisciplinary methods. The damage factors have to be evaluated according to an understanding and interpretation of the physical system.

There is a wide range of different techniques for mural painting and architectural surfaces. In our cultural spheres we can generally characterize architectural surfaces as porous building materials. Mitten (1991:137) describes the characteristics of the specific physical nature of mural painting as follows:

Western Medieval Wall Paintings: Studies and Conservation Experience. Sighisoara, Romania, 31 August-3 September 1995

 ISBN 92-9077-142-9

1. Their constituent materials have a high and open porosity, resulting in an easy accessibility of both liquids and gases (salt solutions, atmospheric pollutants, water vapour, solution of materials used for conservation, etc.).

2. They are – and remain after conservation – part of an essentially open physical system, a consequence of contact with contiguous structures (walls, ground, roofs) that are dynamically involved in a series of physical and chemical events.

3. In most cases the surrounding microclimate cannot be controlled.

We may add that mural paintings and historic renderings are non-homogeneous, multilayered systems.

To understand the system means to know how it resists normal weathering.

Alteration and damage: normal or dramatic

Not every surface alteration has to be interpreted as damage. We must distinguish between normal (i.e., natural) ageing and alterations caused by dramatic damaging processes. Every material is deteriorating. The first and most important question for the conservator-restorer may often be: why has the porous system survived at all? The answer to that question provides the basis on which we can interpret the alteration phenomena, evaluate the damage factors and develop appropriate methods for intervention to treat the causes of damage and not only the symptoms.

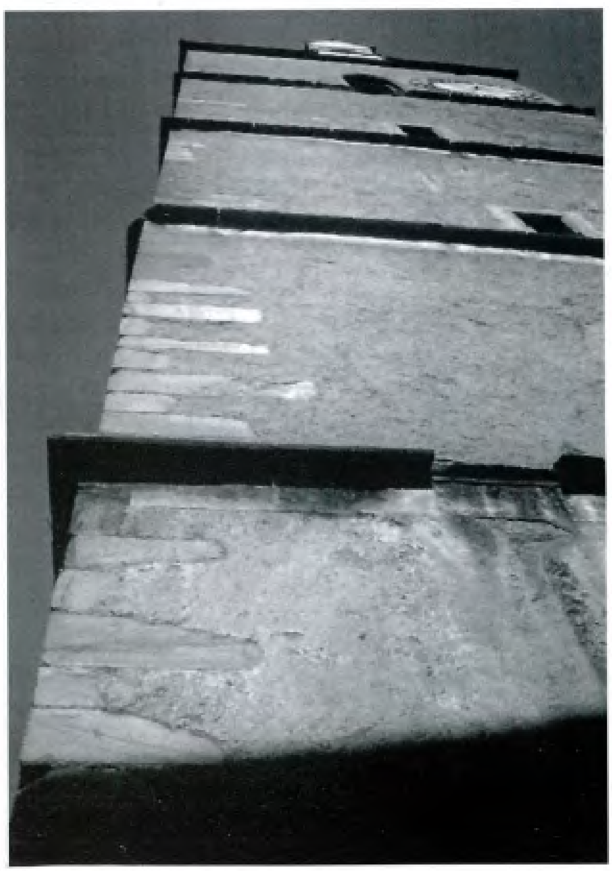


Figure 1. Weissenkirchen, Lower Austria, parochial church, main tower, west facade. Rendering dating from 1502. Photo: Hammer 1989.

Figure 2. Vienna, Scottish Church, south facade, detail. Because of a blocked drainpipe, salts have concentrated in this area. The paint (ca. 1985) was not permeable to water in liquid form. Salts crystallized behind the paint and caused irreversible damage to the rendering. Decay was increased by thermal dilation of the paint containing artificial resin. Photo: Hammer, ca. 1985.

Damage processes (e.g., thermal dilatation, ice pressure, vibration, microbiological infection and crystallization of soluble salts) are not linear, either in frequency or in intensity. They are to be seen as dynamic processes. The importance of alteration phenomena for the dynamics of decay must be examined and interpreted. For example, damage due to soluble salts can originate from different types of dampness. It can be caused by a recent infiltration (e.g., blocked drainpipe) or be the result of slowly rising dampness due to the concentration of soluble salts on the surface in the process of evaporation over hundreds of years.

Evaluation of the dynamics of the damage process determines the urgency of the intervention.

Humidity: origin, amount and transportation

In every handbook, we read that humidity is the main enemy of a structure. Humidity is in fact the main condition for all chemical and biogenic decay and for many types of physical damage.

Nevertheless, water that reaches the capillary system under normal conditions (thermal and hygroscopic condensation, small amounts of infiltration) is not generally harmful. On the contrary, moderate quantities are necessary for the "self-maintenance" of the rendering by the partial solution and recrystallization of calcium carbonate (Paschinger, 1980). On the other hand, large amounts of infiltrating water introduce the physical, chemical and biological factors that cause dramatic damage.

Even recent publications overestimate the importance of water infiltration in the normal alteration process, whereas the two other main sources of humidity, namely thermal and hygroscopic condensation, have not received enough attention so far.

Recent research by Manfred Bogner (commissioned by the Bundesdenkmalamt, Wien) has shown that thermal condensation is a substantial if not the main source of humidity on facades. Thermal condensation develops every night and especially after precipitation. We need to do more research on the depth and quantity of dampness caused by thermal condensation.

Although the hygroscopic behaviour of soluble salts – and salt mixtures – is of course known, its importance for the deterioration of mural paintings and architectural surfaces has not been adequately recognized in the literature for a long time. In the case of the Romanesque wall paintings of Lambach, hygroscopicity was proved to be the main source of dampness. The secondary extension of humidity caused by hygroscopicity was also observed (Hammer, 1991). The soluble salts concentrated on the surface cause humidity to spread even if the original source of dampness no longer exists.

As an answer to the question of why the surface of an historic rendering could resist weathering such a long time and as a conclusion to the discussion of humidity problems, we dare to advance the following – perhaps provocative – thesis:

Highly porous building materials are not dramatically deteriorated by water, if the amount of water is moderate or kept moderate by periodic maintenance. Even if direct infiltration of water could be prevented, there would always be dampness caused by thermal and/or hygroscopic condensation. Originally, rendered surfaces were permeable to water in liquid form. We can conclude that these surfaces have been preserved mostly because by evaporating water could reach the surface in liquid form and therefore could evaporate more quickly (1000 times faster) than through a surface which only allows transportation of water in vapour form (the so-called "breathing" of the rendering). Quick evaporation reduces the possibility of the formation of ice near the rendered surface. Chemical and biogenic mechanisms also have less time to develop. In the process of evaporation of water through porous building material which allows water transportation in liquid form, soluble salts can reach the surface. The salts appear as efflorescence, which can be removed mechanically or washed off by rain.

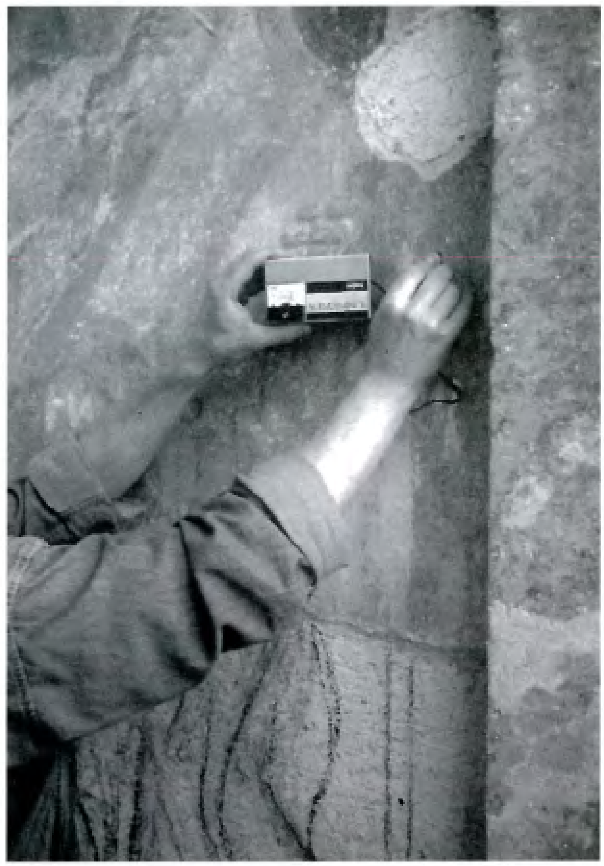


Figure 3. Measuring the electric conductivity of the surface of a mural painting. Photo: Hammer 1986.

Importance of soluble salts as a decay factor

Artisans, architects and engineers have known empirically for centuries that damage in structures is caused by salts. In 1506, for example, Michelangelo complained about efflorescence in his fresco paintings in the Sistine Chapel. Giuliano da San Gallo explained the damage to him as a result of salts and the cold winter climate (pers. comm. M. Koller). However, the central importance of salts in the deterioration of wall paintings and other architectural surfaces has been recognized commonly in literature only recently, in fact only in the last two decades. Although scientific experts concentrated much more on stone conservation, salt problems were studied a good deal in the field of mural painting (see Hammer, 1995). Apart from pioneers like Rathgen (1926), Plenderleith (1957), Vunjak (1957), Taubert (1958) and polish scientists (Lehmann, 1967; Jedrzejewska, 1971), we should note research in this field done by scientists in Florence and Zurich; all of them in close cooperation with conservator-restorers. The interpretation of wall painting and surfaces of architecture in general as a complex physical system, as well as the evaluation of the main causes of damage formed the theoretical basis on which intervention methods could be developed, which on the one hand are adequate to the physical system of porous building materials and on the other hand take into account the main causes of damage. After the flood in Florence in 1966, Enzo Ferroni and the conservator-restorer Dino Dini developed a method for the conservation of mural paintings *in situ*: the famous "Barium method" (Matteini, 1991). Since 1977, the Conservation Institute of the Bundesdenkmalamt, Wien, has developed methods of prefixation and reduction of salts by means of compresses. We have focused not only on wall paintings but also on architectural surfaces in general, mainly historic renderings.

Salts and decay mechanisms

All water in a structure contains salts. They develop their destructive force in the process of evaporation of water near the surface, thus increasing the amount of salt in the evaporation area. As is well known, the origins of soluble salts are groundwater, original building materials, materials for conservation and repair, de-icing salts, biological metabolism, etc. Among these origins, the effect of the polluted atmosphere is sometimes overestimated (Arnold and Zehnder, 1991). In practice it is important to distinguish between the quick transportation of salts caused by evaporation (called convective transportation) (Friese, 1984) and the relatively slow diffusion caused by differences in the concentration of salt solutions. The different solubility of the salts has a so-called chromatographic effect. In the evaporation of rising damp, less soluble salts such as sulphates and carbonates crystallize in lower parts; more soluble salts such as nitrates and chlorides are concentrated in upper parts. Nevertheless, a general horizon of evaporation and salt accumulation can be noticed on the surface of a rendering.

As we know, crystallization takes place under two conditions:

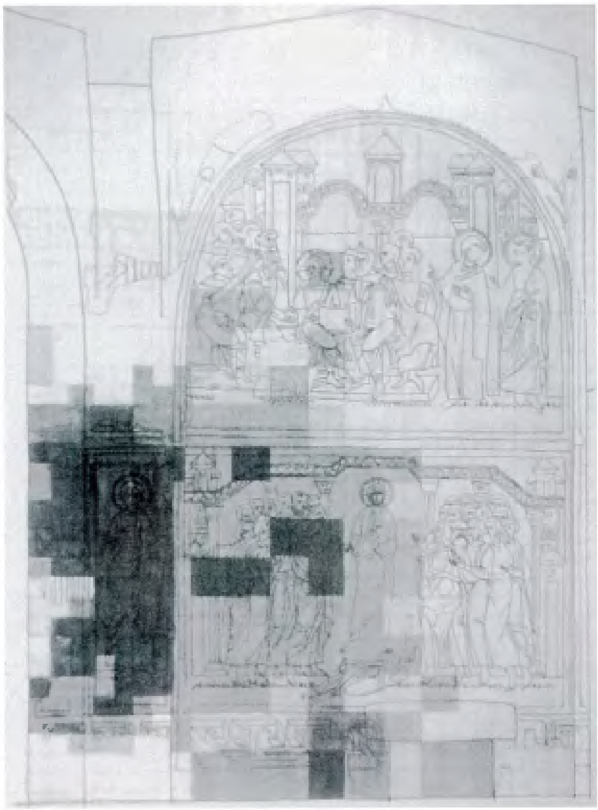
- solution saturation, and
- hygroscopic reaction on the surface of the material (equilibrium relative humidity, RHeq)

"Since actual salt systems are complicated mixtures of ions, the equilibrium relative humidities of pure salts may not apply directly ..." (Arnold and Zehnder, 1991: 114). In the present state of knowledge, the real values of RHeq of a salt mixture can be found only empirically. According to observations in Switzerland and Austria (Hammer & Lux, 1990), the RHeq of salt mixtures was often between *ca* 60% and *ca* 70% RH, depending on higher or lower temperatures. Since gypsum is only slightly soluble (*ca* 20 to 600 times less soluble than the "soluble salts") and does not change much with temperature, this dangerous salt must be seen as a singular case. The slightly soluble salts (besides gypsum, magnesium carbonate should also be mentioned) and the almost insoluble salt, calcium carbonate, form dangerous crusts. Apart from the fact that crusts prevent quick evaporation of water, on facades the importance of the thermal dilatation of crusts should also be taken into account.

Since mural paintings and all architectural surfaces consist of different, non-homogeneous layers, salts tend to crystallize in different zones according to the porosity and cohesion of the layers, also depending on environmental conditions. It is very important for the choice of the intervention method to observe that whiskers of salts do not grow in all directions, but first use the space of the pores; in other words, damage depends on the quantity and concentration of the salts. Crystallization starts in pores of 1-10 μm size. The pressure of crystallization physically breaks the mechanical cohesion of the carbonate crystals of the rendering and the binding media of the paint layer. Decay mechanisms do not work in a linear way but dynamically. The visible phenomena are often only the end of a longer process.

Methods of examination

The methods of examination must reflect the fact that mural paintings and architectural surfaces in general are part of a whole building: they are neither aesthetically nor technologically autonomous.



Figures 4 - 7 (clockwise from upper left): Lambach / Upper Austria, monastery church, former west choir, wall paintings around 1080. Periodical measurement of electric conductivity. 1972. (4): Infiltration in the area left of the pillar. 1979 (5): Three years after the removal of the source of infiltration the contaminated area is extended owing to hygroscopic reaction. 1980. (6): Removal of soluble salts by means of poulticing. 1981. (7): After pre-fixation and poulticing, the electrical conductivity is reduced considerably. No further damage has been observed since. Bundesdenkmalamt, Wien. Photo: Hammer 1980.

Interdisciplinary research and examination are therefore necessary and are recommended at every congress. In practice, however, the interpretation of the mass of scientific data collected and the transformation of such diagnoses into suitable intervention methods is still a critical point. As all possible scientific examination cannot be executed in every case, it might be useful to mention some of the methods the conservator-restorer could apply for a (first) orientation and thus avoid a merely empirical approach.

Apart from the usual examination, description and documentation of the materials and technique of the original surface and support, the later alterations and the state of conservation of both original and later additions (using optical resources like magnifier, portable microscope, raking light, etc.), we mention the following methods as examples:

- definition and monitoring of reference areas;
- measuring and documentation of climate at different times (temperature, RH, wall temperature, precipitation, insolation) at least with a psychrometer (if monitoring the climate over a full year is not possible);
- measuring the electric conductivity of the surface. It is true that a single value is not meaningful by itself, but statistically the values are significant. Nevertheless, the results of electric capacity measurements near the surface cannot always be easily interpreted (Hammer, 1987);
- measuring the absolute moisture content of samples (taken from different depths) by using the calcium carbide method (CM). In our work this method proved to be much quicker than the method of drying out samples in the laboratory and it turned out to be precise enough.

As an example, let us presume that the measurement of electric conductivity of the surface, executed during 80% RH, reveals significantly higher values than the same measurement executed during 50% RH. Then we can deduce that this result indicates the existence of hygroscopic salts on the surface. If the CM-measuring shows decreasing values in depth, whereas the electric conductivity of the surface is high at the same time, we can assume that humidity is caused by thermal or hygroscopic condensation and not by rising damp.

Already at the examination stage, the conservator-restorer should be aware of the need for preservation of the historic monument as a whole. Interventions aiming at the stability of the structure or protection against water infiltration must be carried out in cooperation with the conservator-restorer. The drying out of a wall could increase the damage caused by soluble salts on a wall painting.

Remarks on current treatment of humidity and salts

The current and often-employed treatment of mural painting and historic architectural surfaces deteriorated by humidity and salts may be critically described under two interdependent aspects:

- radical intervention, often not necessary; and/or
- cosmetic intervention, making the decay phenomena invisible without treating the causes of decay.

The misinterpretation discussed above, i.e., that any water causes damage to an historic structure, leads to interventions that are often not necessary, too radical and defective. It is not true that ancient walls have no horizontal isolation to provide protection against rising dampness. Walls built of rough stones, mostly with a high density, were very common in Austria up to the 17th century. There is often not a great amount of rising damp. Brick walls are often built with clay mortar, at least at the foundation level. Therefore expensive isolation of ancient walls at the base or at the sides is often not necessary and sometimes even defective. Cement or other materials containing alkaline salts which are used for isolation cause irreversible damage to the surface (Arnold, 1985; Arnold and Zehnder, 1991). In most cases, however, the hygroscopic reaction of the salts concentrated at the evaporation horizon – that is, above the level of horizontal isolation – does not stop. We must conclude that in many cases, lots of money is spent in vain for horizontal isolation of ancient buildings and it does not address the main cause of damage.

The widespread use of highly porous renderings in the socle area of a building must be classified under the second criterion: mere cosmetic intervention. These "cosmetic" renderings, mostly containing cement, have such a high porosity (pore size more than 5^{-5} m) that water cannot be transported in the capillaries in liquid form but in vapour form only. Thus dampness is not visible on the surface. These renderings (the German scientific and euphemistic term is *Sanierputz*) work as a barrier to evaporation because water cannot reach the surface in liquid

Figure 8. Dürnstein, Lower Austria, former monastery church, crypt, Stucco work and mural painting 17th/18th c. Desalting poultices consisting of different structures: beech cellulose pulps partly stabilized with lime rendering with thin Japanese paper as intermediate layer; lime rendering with polyamide sheet as intermediate layer; note the hygroscopic stains on the compress rendering. Photo: Hammer 1986.

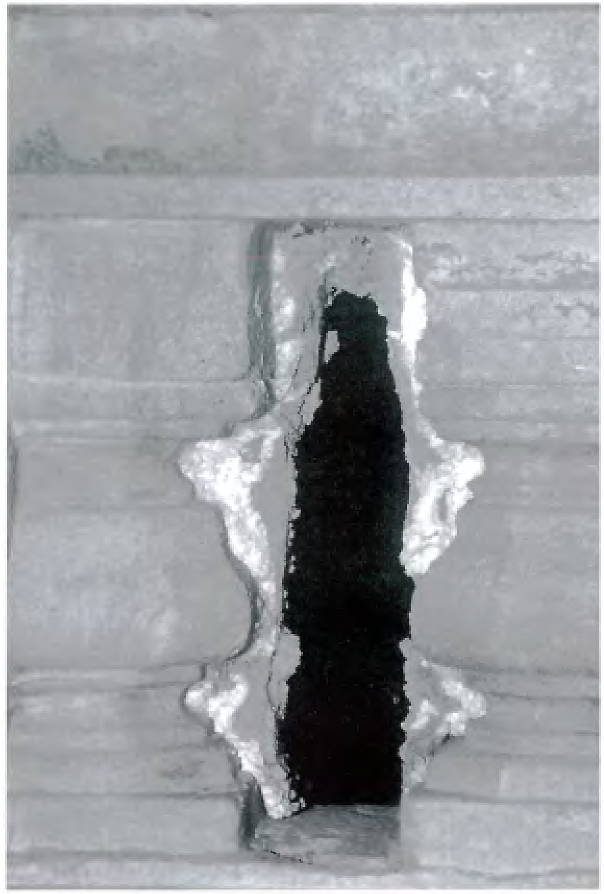


Figure 9. Dürnstein, Lower Austria, former monastery church, crypt, limestone balustrades 17th c. Structure of the desalting compress: beech cellulose stabilized with lime rendering. Photo: Bundesdenkmalamt, Wien, 1987.

form. Current practice and research, however, ignore this defective effect. Apart from the evaporation barrier, we must also emphasize that the soluble salts located in the area between this kind of rendering and the wall also deteriorate the surface of the original, an effect which is even increased by the current preparation of the wall with cement (in German *Vorspritzer*). The hygroscopicity of the salts prevents the phenomenon of thermal insulation provided by this kind of rendering. They cannot be whitewashed with lime because lime needs capillary contact with the wall to carbonate and adhere properly.

If we accept the interpretation of highly porous building materials as an "essentially open physical system" (Matteini, 1991), the positive effect of applying silicones to avoid infiltration of water is doubtful. It prevents the "self-maintenance" of the calcium carbonate. Coating with hydrophobe silicones also works as an evaporation barier. Even if water cannot infiltrate from the outside, it is present through thermal condensation and hygroscopic reaction (not to mention possible infiltration through the cracks of ancient buildings). This favours the development of chemical and microbiological deterioration factors behind the hydrophobic film on the surface.

Treatment of salts

One of the most important ways to treat salts is the prevention of infiltration and condensation of damaging quantities of water. If the drainage system and other methods of keeping away damaging quantities of water from the structure are working or have been adequately repaired or improved, we can distinguish two different approaches in the methods of treatment of salts:

- the passive method: conditioning of the climate inside the building; and
- active methods:

Figure 10. Dürnstein, Lower Austria, former monastery, cloister, vault. Lime stucco work contaminated with soluble salts. Removal of soluble salts by means of lime mortar. A recent glue paint served as a protecting and separating layer. Photo: Hammer 1987.

Figure 11. Grades / Kärnten, filial church, 15th century, south facade, detail. A thunderstorm caused considerable infiltration of water. The recently restored facade painting was stained by hygroscopic salts. The stains were removed by a compress rendering put on for a weekend. Photo: Hammer 1987.

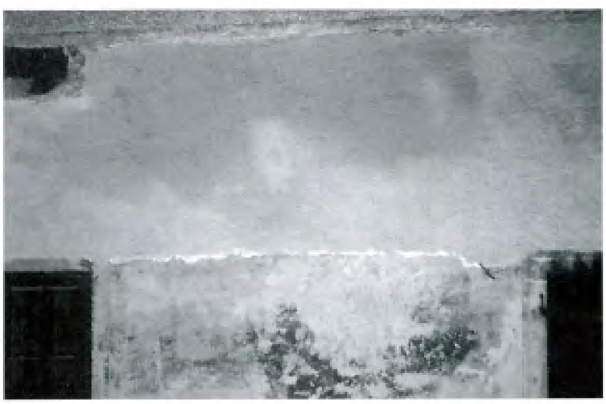


Figure 12. Forchtenstein, Burgenland, castle, main court, facade painting 1687. Desalting poultice stabilized with lime rendering. Photo: Hammer 1992.

– reduction of disruptive salts

– removal of salts (desalination) or

– immobilization of salts.

Conditioning of climate

Inside a building, variations in relative humidity (RH) can be prevented by conditioning the climate. In practice this means stabilizing the RH and temperature of a room at a value higher than the empirically found value of equilibrium relative humidity (RHeq) of the salt mixtures concentrated near the surfaces of the rendered (and painted) walls. As mentioned above, the RHeq can only be found empirically. This method should be used in urgent cases only because an increase in RH favours the growth of micro-organisms even if the temperature is kept as low as possible. In this context we have to bear in mind that the lower the temperature, the higher the value of RHeq. The rise of RH might also be dangerous if particles of the paint layer of a mural painting adhere to the support only by the mechanical stability of the salt crystals.

Reduction of the quantity of disruptive salts

In order to make an adequate choice of the method of removing salts, we must distinguish between soluble salts such as potassium sulphate or sodium nitrate (at least 25 times more soluble than gypsum), slightly soluble salts like gypsum or even magnesium carbonate, and salts that are nearly insoluble in water, such as calcium carbonate or barium sulphate (Matteini, 1991). The soluble salts located and concentrated near the surface are removed to the extent that their concentration with relation to the space of the pores is not dangerous and that the salts do not disturb aesthetically. Many methods of salt removal are often identical with current cleaning methods. As the very existence of mural paintings depends on the preservation of a thin paint layer of the order of some 10 μm thick, the range of methods is smaller than the methods one can use for the "desalination" of architectural surfaces in general. Slightly soluble salts like gypsum, and crust-forming salts as well, can only be removed mechanically or after chemical transformation. The different possibilities for the reduction of disruptive and crust forming salts often have to be combined. In practice, their importance for the preservation of wall paintings and architectural surfaces differs. Some methods, such as those using compresses, are now standard. Others need to be developed for possible practical use. Some are dangerous and should only be used under certain cir-

Figure 13. Weissenkirchen, Lower Austria, parochial church, tower dating from the 14th century with original rendering. Cleaning with poultices containing ammonium carbonate. Photo: Hammer 1989.

Figure 14. Forchtenstein / Burgenland, castle, main court, facade painting 1687, east facade. Removal of the last desalting compress after treatment with ammonium carbonate and ammonium bicarbonate. Photo: Hammer 1993.

cumstances. These various methods for treating salts may be generally listed as follows:

A) Methods of removal:

- mechanical removal
- drying out and mechanical removal
- solution in water and removal of the solution
- chemical transformation and removal of the solution
- electrochemical dissociation and removal of the ions.

B) Methods of immobilization

Mechanical removal

Even if the salts tend to concentrate near the surface, the efflorescence is mostly only part of the salts located in the porous material. Therefore the mechanical removal of blooming salts may be a helpful first step but cannot compensate for the removal of actually dissolved salts or of subflorescence. As for mural paintings, crusts may be removed mainly with mechanical methods using the wide range of abrasive micro-sized tools (sand-blasting, rotating glass fibre or rubber gum, vibrating chisels). One of the oldest methods of removing salts is the demolition of the ancient salt-affected rendering, even if it was not executed consciously for the purpose of "desalination" but only because of the disregard of the historic rendering as an exchangeable coating.

Drying out

The natural process of transportation of salts towards the surface by evaporation of water in porous building materials, especially mural paintings, could be accelerated by applying heat (e.g., by infrared light, blow drier, microwaves, fast-evaporating solvents). To our knowledge there are not yet any publications about practical experiences. This method works only if the surface is permeable to water in liquid form. Even if possible damage on the surface could be avoided with a protective poultice, quick evaporation could lead to dangerous subflorescence. If the poultice is not applied, the efflorescence must be removed mechanically. The proposed use of hydrophobic silicones (Pühringer and Weber, 1990) would change important features of the physical system of the porous building material and also cause subflorescence.

Wet cleaning, flooding

The flooding of mural paintings with small amounts of water which is removed with a (natural) sponge is a currently used cleaning method with a certain desalting effect. In the case of gypsum, however, water can cause a white veil due to the slight solubility of gypsum. If gypsum is the product of a chemical transformation of calcium carbonate, larger amounts of water can lead to a dramatic weakness of the cohesion of the paint layer.

The cleaning of rendered historical facades with large amounts of water is therefore also dangerous for the exterior and can stimulate the growth of micro-organisms in the interior of the building (Koller, 1988). Instead we prefer to use steam at a relatively low pressure depending on the mechanical stability of the surface (*ca* 30-50 bar). The heat of the vapour at *ca* 150°C also disinfects the surface. Salts concentrated on the surface cannot be removed with this method, so compresses are also required (see below).

Removal of disruptive salts by means of poultices: mechanism and materials

Hydrophilic material containing de-mineralized water is applied to the surface of the porous building material affected by salts. The porous surface absorbs the water, the salts dissolve and are initially transported to a certain depth of the material. At the same time, the poultice begins to dry. The convective transportation of the salt solution towards the surface starts when the poultice contains less water than the porous building material itself. The poultice serves as an expanded environment of the rendered wall. In the process of evaporation the salts concentrate and crystallize in the poultice without deteriorating the original surface. It is highly important that, until it is removed, the poultice stay in capillary contact with the original surface. In literature concerning stone conservation, there are very mixed opinions about whether poultices should be wet or dry when removed (Friese, 1984; Windheimer *et al.*, 1991; Grassegger and Grüner, 1993). The effectiveness of poultices seems to depend a good deal on the length of contact time and the pore structure of the surface. Effectiveness did not change if the poultice was humidified during the process of evaporation and drying out or if the evaporation time was extended by covering the poultice with a polyethylene foil (Ettl & Schuh, 1992). In our experience on mural paintings and historic renderings, relatively thin poultices with a thickness of *ca* 1 cm drying out quickly had a good effect. In order to prevent the transportation of salts to unaffected areas, the poultices must always be larger than the contaminated parts. Thin Japanese paper improves the extent of capillary contact of the poultice with the surface and is used as a protective intermediate layer at the same time (pers. comm., Sabino Giovannoni, Florence, OPD, 1981; Matteini, 1991). Materials added to the poultice, such as sand, could reduce shrinkage. On facades, the hydrophilic material of the poultice has to be protected against driving rain; on curved surfaces inside a building, the poultice also tends to lose capillary contact due to shrinkage. In such cases we developed a way to stabilize the poultice: when the poultice is dried out slightly but still wet, we coat it with normal lime mortar (1 part slaked lime-powder, 3 parts sand 0-4 mm grains), the first layer very thin, then thicker up to a size of *ca* 1 cm. The alkaline lime prevents microbiological deterioration of the cellulose poultice. The use of disinfectants with poultices is not advisable because the balance of micro-organisms may be disturbed (Petersen and Hammer, 1993). Instead of application by hand, the poultice can also be sprayed on (Leitner, 1988); the disadvantage of this method is that Japanese paper cannot be used.

In early literature concerning the use of poultices, various materials such as paper pulp and kaolin mixed with sand are mentioned. Since 1967, an artificial cellulose produced by MONTEDISON has been used in Florence in the process of the barium method. In 1978, our laboratory (Hubert Paschinger) learned of the beech cellulose ARBOCEL, in powdered form which is now used internationally (Johann Rettenmaier & Sons, D-73494 Ellwangen). ARBOCEL is supplied with cellulose fibres of different lengths (BC 1000, the most common; BC 200; BWW 40) (Hammer, 1995). One compress is often effective enough on highly porous historic renderings, whereas several compresses are required on mural paintings with a certain surface density. In the above-mentioned case of Lambach, we changed the poultice every three weeks, using 4 compresses in total. In order to prevent crystallization and efflorescence, the last poultice should be dry in any case when removed. According to our experience, e.g., with the Romanesque wall paintings in Lambach, the efflorescence remained active to some extent in some areas. After the treatment (1979-1981), there was apparently enough pore space so that the salt whiskers did not have any destructive effect. These areas are maintained with poultices once a year.

Rendering as a medium for removal of salts (compress rendering)

Since 1984 we have used normal lime mortar as a porous pack to remove soluble salts from historical renderings on facades as well as inside a building (Heimannn, 1981; Ashurst, 1988). This method can be employed by any construction company and is now part of nearly every repair process for surfaces of ancient architecture. Frequent salt affliction near the foundation level can be treated at low cost and without scaffolding. Demolition of the old rendering is not even necessary. The most effective time of application is autumn; if it is detached on a cold day in spring, the highest quantity of salts would crystallize in this compress-rendering. Due to the reaction with lime, soluble sulphates can be transformed into gypsum. This method is therefore less effective than a cellulose poultice and should not be used on mural paintings (Hammer, 1995).

Chemical transformation of salts and their removal

Generally this method is applicable for some slightly soluble salts and crusts. Because of lack of space we can only list here some of the possible methods.

The use of strong acids for the removal of a crust of calcium carbonate is one of the dark points in the history of conservation of wall paintings. If in exceptional cases the use of an acid such as formic acid or acetic acid is inevitable, the salts produced by this method have to be removed by water compresses.

Since 1981 we have used hexafluoric acid (*ca* 1:5 in water) in the repair of renderings and as a preparation for lime washes on facades. The method is known in the process of application of facade paints using potassium silicate as a binding medium. The treatment has several effects: partial removal of the crust so that porosity is again open to the surface; disinfection; slight consolidation effect on the original rendering; slight hydraulic effect on the subsequent fillings and lime paint.

The cleaning effect of ammonium carbonate has been well known in Austria since 1955 (Hammer, 1995; Plenderleith, 1956). In this respect the case of the facade paintings (1687) of Castle Forchtenstein/Burgenland might be interesting. We applied poultices partly with ammonium carbonate and partly with a mixture of ammonium carbonate and ammonium bicarbonate and let them dry out, exploiting the desalting effect of the compress (Hammer, 1993). This "mixed" poultice was also used in the case of the historic rendering (around 1300 and 15th c.) of St Ursula Chapel in Krems. After cleaning, a poultice containing water (water compress) was necessary.

For other procedures of this kind, such as the *papetta* Mora (AB 57) (Mora and Mora Sbordoni, 1976; Fritz 1992) and ion-exchange resins (Giovagnoli *et al.*, 1979; Pizzigoni *et al.*, 1989), see the literature. As for methods of immobilization of salts, only the following can be mentioned here: Pb-hexafluoric silicate is sometimes used on renderings of facades to transform sulphates, mainly calcium sulphate. It must be borne in mind that other salts such as nitrates and chlorides cannot be transformed into insoluble compounds. For mural paintings, the famous barium method developed in Florence has been used since 1981 in cooperation with Florentine colleagues and with Heinz Leitner in Austria (Ferroni *et al.* 1969; Matteini, 1991).

Pre-fixation

The surface of a mural painting must be stable enough to resist the mechanical stress of a poultice applied to remove disruptive salts. The fixation material must not dilute the salts and must not block the open capillarity of the porous surface. If there is lack of cohesion between the rendering and the wall, the capillary contact of both has to be recovered by infiltrating an adequate liquid mortar before "desalting." This is a necessary requirement for an effective desalting poultice. In order to maintain the physical structure of the porous surface, the fixation material must have a mineral quality. The hydrophilic character of the surface is not only necessary for the treatment with desalting poultices, but also to prevent physical changes that prejudice later interventions. A disadvantage of this method is that subsequent cleaning is more difficult. It is an open question as to which materials should be used. The tetramethoxysilane (MKSE) we have used is no longer available. Some of the currently available ethyl silicates might have less hydrophobic properties than previously used types. More research on this aspect is required. In the context of the barium method, thin layers of HAMMARSTEN casein were successfully used as a partial fixation medium.

Résumé:

Interventions de conservation/restauration sur peintures murales et autres surfaces architecturales concentrées uniquement aux symptômes de la dégradation souvent apportent a l'augmentation de la détérioration plus qu' à la préservation du bien culturel. Les interventions doivent être liées avec

une compréhension structurelle du système physique des matériaux poreux de construction et dirigées à la conservation de ce système. A cause d'une évaluation des facteurs de la détérioration il faut distinguer entre le processus d'altération normale, c'est-à-dire le vieillissement et des processus de dégradation dramatiques causés par des facteurs exceptionnels. Ces remarques reflètent le point de vue interdisciplinaire d'un conservateur/restaurateur. Finalement on présent une liste de méthodes de traitement des sels nocives avec quelques commentaires.

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SCIENTIFIC EXAMINATION OF MEDIEVAL WALL PAINTINGS

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ABSTRACT

The technical sophistication of English medieval wall paintings has been fully established during the first three years of a comprehensive study, funded by the Leverhulme Trust, of medieval wall painting techniques. This five-year study is based on both scientific examination and documentary evidence and covers both a chronological and geographic distribution of paintings. Results have indicated that, generally, techniques appear to be more complex than previously supposed and mixed media have frequently been used. This means that not only may the binding medium vary from layer to layer, or from one area to another, but also that more than one medium may be present in a single paint layer. Unexpected results also include the use of oil as a binding medium as early as 1130. In some cases, complex pigment alterations have been established which may relate to conservation treatments used in the past.

Keywords: wall painting, medieval, technique, scientific examination, pigments, binding media.

Introduction

The results of three case studies illustrate the complexity of the techniques of English medieval wall paintings.[1] Two of the studies relate to the scientific examination of Romanesque wall paintings – in St. Gabriel's Chapel, Canterbury Cathedral and the Holy Sepulchre Chapel, Winchester Cathedral – and one to the examination of the late 14th-century polychromy in the Chapel of Our Lady Undercroft, Canterbury Cathedral.

St. Gabriel's Chapel, Canterbury Cathedral

Although these paintings have been described as the 'finest example of a northern European fresco technique'[2] – and this unsubstantiated view has been persistently held – analysis has established not only that they are certainly not fresco, but that overall the technique is remarkably complex.

Much of the evidence for plaster joins is now difficult to establish because of the detachment of the paintings during conservation work in 1967-72; however, it is clear that on the north side of the apse there are three fragmentary, roughly horizontal joins dividing the two narrative registers into four bands. Figure 1 shows that none of these plaster bands conform to the divisions of the composition, and indeed they arbitrarily cut through them. Examination in raking light indicates that the lowest plaster join corresponds to the change in construction material from ashlar masonry to the rubble of the curved vault. This evidence suggests that the paintings are likely to be coeval with the building of the chapel *ca* 1125-1130 and are not therefore of *ca* 1155-1160, as has been previously thought.

Preparatory techniques

There appears to be no evidence of overall setting out with snapped or incised lines, but this is not surprising since neither the curved surfaces nor composition lend themselves to this. The roundels on the entrance arch soffits, however, were set out with compasses.

Initial underdrawing in yellow earth is visible wherever the subsequent paint layers have been lost. The pale colours facilitated correction, and *pentimenti* are evident, particularly in the lower register on the north wall. This preliminary sketch was then refined and finalized in red earth as can

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clearly be seen in the setting out of the meander pattern and busts on the entrance arch soffits. Then the basic background colours – red and yellow earth, and carbon black – were blocked in. All this preparatory work seems to have been done in the fresh plaster, indicating that the plastering and painting are coeval.

Pigments and their application

The palette was very rich, including cinnabar (natural vermilion) and a large quantity of extremely high quality natural ultramarine. The present examination has identified the following pigments: natural ultramarine ($Na_{8\text{-}10}Al_6Si_6O_{24}S_{2\text{-}4}$), malachite ($CuCO_3Cu[OH]_2$), vermilion ($HgS$), red lead ($Pb_3O_4$), red iron oxide ($Fe_2O_3$), yellow iron oxide ($Fe_2O_3H_20$), lead white ($2PbCO_3Pb[OH]_2$), lime white ($CaCO_3$), and carbon black (C). The palette was substantially extended by layering and mixing.

Frequently, complex layer structures were used to produce subtle effects, such as for the shadow on the foot of the southern angel supporting the mandorla: two layers of yellow earth in a lime matrix – the second containing a greater proportion of yellow earth – were applied over the lime plaster; over this, a layer of cinnabar combined with charcoal black was applied to produce the shadow on the flesh tone. For highlights in the flesh painting, layers of varying combinations of yellow earth and lime white were applied, ending with lime white highlights in thick impasto, which are dramatically visible in ultraviolet light. Interestingly, a localised and intermediate lead white ground was applied in specific areas: for example, for red drapery, a lead white ground was applied over the first paint layer of yellow earth in a lime white matrix in preparation for an upper layer of cinnabar in a red lead matrix.

To further extend the palette, pigment mixtures were widely employed. This is particularly important in relation to the green pigments since the only mineral green identified – malachite – was found only on the column capital. In all other cases, the greens were made by combining natural ultramarine and yellow earth in a lime matrix. Frequently, cinnabar was combined with red lead, though this probably served to extend the more expensive pigment rather than to produce colouristic effects.

Media

Analysis undertaken initially by microchemical tests on thin sections was followed by analysis of some samples by Fourier Transform Infrared microspectroscopy (FTIR) and gas chromatography-mass spectrometry (GC-MS).[3] Both protein and oil were identified as part of the original technique. In a sample from the blue robe of the *Christ in Majesty,* small quantities of protein were found in both the ultramarine layer and in the red and charcoal black underpainting.

Both a proteinaceous component and linseed oil were detected in a sample from the ultramarine background, the very low count-rate of the GC-MS suggesting a small quantity of oil. Linseed oil was also found with GC-MS in a layer of malachite and lead white on the column capital. Again the paint layer appeared to be rather leanly bound, but the linseed oil content is significant and its presence is not due to conservation treatment. No oil was present in the lower layer of red earth and charcoal black, but a proteinaceous component suggested a glue.

These findings regarding the original media are extremely important since they push back the earliest confirmed use of oil in English medieval wall paintings from the previously documented and analytically substantiated date of 1237.[4] Oil has, however, been identified in much earlier wall paintings on the continent – in the Carolingian scheme at Müstair of *ca* 800 [5] – suggesting that finding oil is largely a function of having reliable instrumental analysis. Although instrumental analysis of the media of comparable continental wall paintings is rare, it is significant that when available it indicates similar findings, as at Idensen where the presence of a proteinaceous binding medium is associated with blue and green pigments.[6]

Holy Sepulchre Chapel, Winchester Cathedral

The technique of the exquisite Romanesque wall paintings in the Holy Sepulchre Chapel – which date from *ca* 1175 – is rooted in the tradition of painting *a fresco*. However, an additional proteinaceous binding medium and also lead pigments have been identified, which, together with the sweeping compositional changes made at an advanced stage of the painting process, suggest that significant portions were completed *a secco.*

The most striking area of late 12th-century painting is on the east wall of the Chapel, comprising a *Deposition* in the upper register, and, below the dividing geometric border, an *Entombment* with the *Maries at the Sepulchre* and the *Harrowing of Hell.*

Figure 1. St. Gabriel's Chapel, Canterbury Cathedral. Diagram of the painting on the N side of the apse, showing the position of plaster joins, indicated in red. Areas, originally red in colour but now covered with a grey 'crust' are indicated with dark hatching.

Plaster

There are two principal horizontal zones of plaster corresponding to the narrative registers, and another for the ornamental border which divides these registers (Figure 2). Additionally, within each of the principal plaster zones, there are further divisions which roughly conform to the various individual figures or groups of figures. These secondary plaster joins, many of which are rather indistinct – particularly in the lower register – make understanding of the plastering sequence problematic. It is evident, however, that the narrow central plaster patch for the geometric border was applied before the plastering of either of the narrative registers. In the upper register, the roughly executed plaster joins, applied wet over dry, clearly indicate that the patch for the central cross was applied first, followed by that for the main figure group, and finally those for the flanking figures. By contrast, the plaster joins in the lower register are indistinct, and the application appears to have been 'wet on wet', allowing the edges to merge. Careful examination of the surface in raking light does, however, indicate that the central portion may have been applied first.

Preparatory techniques

The existence of a *sinopia* on the east wall – traces of which are visible where tiny losses in the intonaco exist – was noted by Park.[7] Evidence from the stratigraphy of the plaster, and from the examination of cross-sections – such as one sample which shows a trace of red pigment (red earth with some vermilion) beneath approximately 0.4 cm of plaster – suggests that the sinopia was applied either directly on to the ashlar support or on the levelling plaster.

Examination of the surface of the Romanesque plaster in raking light revealed the use of snapped lines marking the position of the central ornamental border. The geometric elements within the border were set out by incision into the wet plaster with the aid of a compass. When this border was moved to a slightly lower position, new incisions were made, but in this case a slightly different quality of line is evident since the plaster was clearly no longer as fresh. Incision into the wet plaster is evident in other distinct areas, as in Christ's arm and the flagon of holy oil in the *Entombment*. In addition a preparatory drawing in yellow iron oxide – clearly visible wherever the

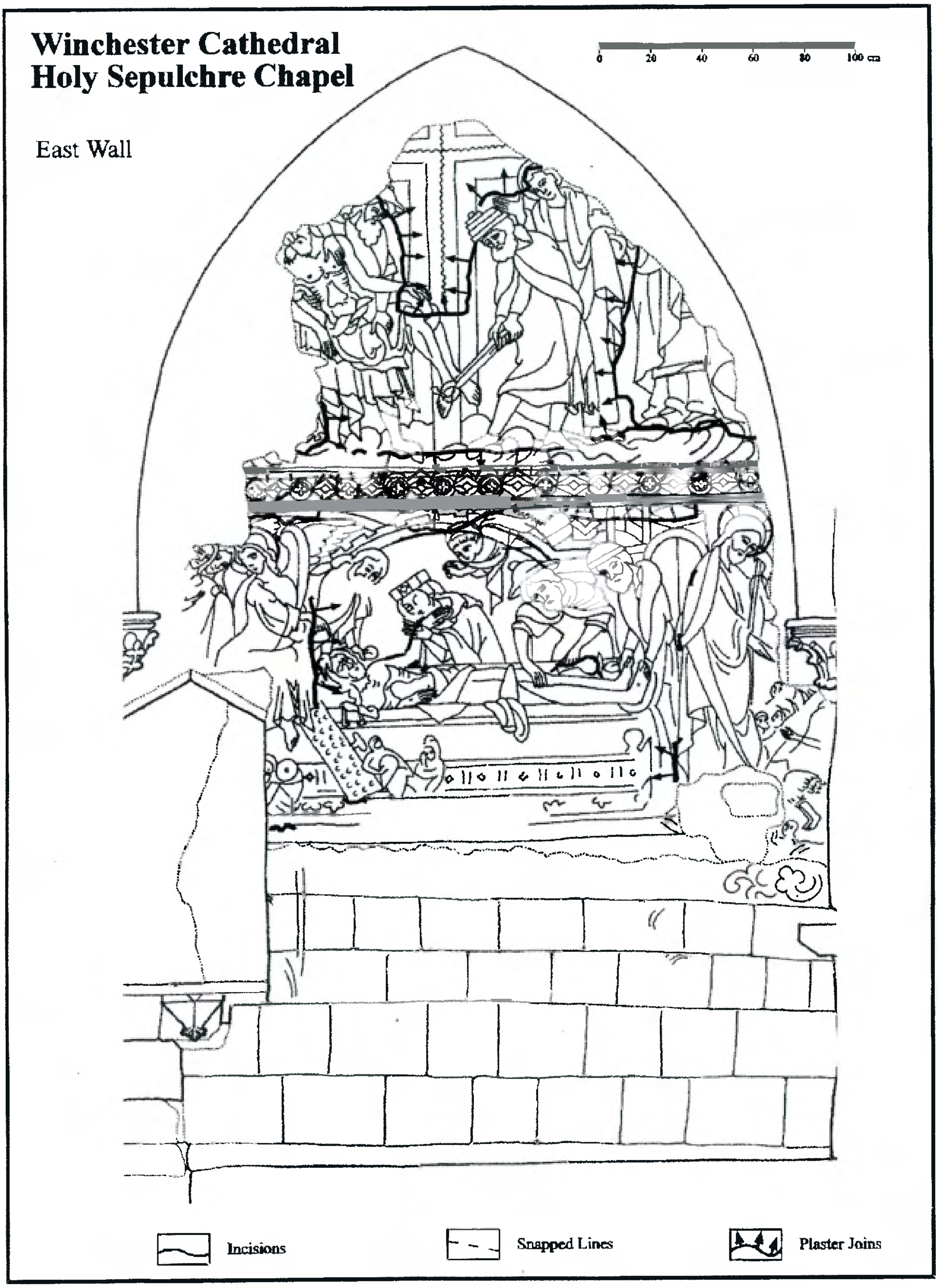

Figure 2. Map of plaster zones.

paint layers have been lost – was used to place the main pictorial elements within the visual field.

Pentimenti

The Romanesque paintings are particularly fascinating from the point of view of the changes made by the painter at an advanced stage of the painting process. This is particularly evident in the *Entombment*, where, to the left of the Virgin's head, the remains of another head and a broad-brimmed hat can just be seen, indicating the original position of the figure anointing Christ's body with oil (in the final version placed to the right of the Virgin).

Many other alterations are visible. For instance, the figure of St John in the *Deposition* was finally painted with his hand gesturing towards Christ, but the yellow preliminary drawing indicates that he was originally conceived with his hand held to his face in grief.

Palette

The research has established that the palette of the Romanesque paintings included: gold leaf (Au); natural ultramarine ($3Na_2O·3Al_2O_3.6SiO_2.2Na_2S$); vivianite ($Fe_3 + 2[PO_4]_2.8H_2O$); vermilion (HgS); red lake; red lead (Pb_3O_4); haematite (Fe_2O_3); green earth ($K[Al,Fe^{III}]·(Fe^{II},Mg)]·(AlSi_3,Si_4)O_{10}(OH)_2$); yellow iron oxide ($Fe_2O_3.H_2O$); and lime white ($CaCO_3$).

One of the most interesting findings is that red lake was used for the unusual pink colour of Nicodemus' robe. This is the earliest identification of this pigment in English wall painting, though at Müstair (Switzerland) a red lake pigment – thought to be madder – has been identified in the Carolinian scheme of *ca* 800. [8]

The inclusion of vivianite in the palette is particularly surprising, not only since this pigment has not previously been identified in English medieval wall painting, but also since it was clearly selected for its distinctive colouristic qualities, rather than as an economic alternative to other mineral blues.[9] The characteristic deep 'indigo' blue of vivianite – played against a pale blue of natural ultramarine combined with lime white – was employed for the central details on the vair lining of Nicodemus' cloak in the *Deposition*. Although the iron phosphate mineral has now altered and appears green, an examination of the Morgan leaf from the Winchester Bible of *ca* 1170-80, shows that there vair linings were represented by pale blue elements with a dark blue centre, and it is clear that this was also the intention in the wall paintings.

Binding media

Analysis undertaken initially by microchemical tests on thin sections and cross-sections was followed in some cases by FTIR microspectroscopy. Results confirmed that although the carbonation of lime is the principal binding mechanism, a proteinaceous component is also present in some samples: for example, in a paint layer consisting of red lead, lead white and calcium carbonate in a sample taken from the impasto decoration of the geometric border. Likewise, a proteinaceous component has been identified in a layer of calcium carbonate applied beneath a resinous mordant for gold leaf in a sample from the halo of the angel in the *Entombment*.

Application

The presence of a sinopia, and the application of the intonaco in overlapping patches, indicate that the primary binding mechanism for the pigments was the carbonation of calcium hydroxide from the lime plaster: that is, at least the preliminary drawing and initial pigment layers were applied a fresco. However, the stratigraphy of the final painting is remarkably complex, and varies substantially across the pictorial surface, from thin single layers applied directly on the lime plaster substrate to paint applied in considerable impasto, often over coloured grounds.

Chapel of Our Lady Undercroft, Canterbury Cathedral

The chapel occupies the two easternmost bays of the central aisle of the crypt of Canterbury Cathedral. Although dating originally from the Romanesque period, the chapel was much altered in the second half of the 14th century, when it was surrounded on the north, east and south sides by elaborate stone screens. These screens, and the vault of the eastern bay, retain much of their sumptuous decoration in painting and relief. Both the architectural alterations and the decoration probably date from about the 1370s, and may well be connected with the Black Prince (d.1376) who desired to be buried in this chapel.[10]

Pigments and their application

Until the recent conservation programme (1986-91), the background to the relief suns and stars on the vault was blue-black in appearance. It was generally considered that it had originally been painted in blue or black, though, in 1977, Winfield had recorded the colour as 'a brilliant red, which is probably vermilion, now badly blackened.'[11]

Cleaning tests carried out in 1986 by the Canterbury Cathedral Wallpainting Workshop, together with sampling undertaken by the Courtauld Institute at that time, showed that the original colour of the vault was indeed a brilliant red. Over a preparation layer of calcium sulphate (gesso), a layer of red lead was applied, which in turn was covered by a vermilion glaze, providing a rich effect. Tests showed that the dark appearance was not due to the alteration of vermilion, but resulted from a layer of carbon black (probably lampblack from candle burning) combined with wax in a sulphated crust on the surface, and further reinforced with retouchings in blue.[12] The recent conservation, involving extensive testing to find a suitable cleaning method, has now returned the vault to its original red appearance.[13]

The screens of the chapel are decorated with barber-pole, diaper and marble designs in red, green, blue and gold, while silver leaf was used on the canopy of the niche on the reredos, which probably originally contained an image of the Virgin. The original palette included natural azurite ($2CuCO_3.Cu(OH)_2$); vermilion (HgS); basic verdigris $Cu(C_2H_3O_2)_2.2Cu(OH)_2$ and copper resinate; red lead (Pb_3O_4); charcoal black (C); red iron oxide (Fe_2O_3);, yellow iron oxide ($Fe_2O_3.H_2O$); gold (Au) and silver leaf (Ag). As on the vault, the pigments were applied over a calcium sulphate preparation layer, which would have enhanced the colours by reflecting light through the paint layers. A secondary ground of charcoal black combined with calcium sulphate was used beneath the azurite to increase its covering power. In several samples there is evidence of the transformation of the azurite to a green copper compound.

The gilding is often very well preserved. It was most frequently applied to the raised decorative elements, though the central niche in the eastern screen is entirely gilded. Gold leaf was applied over an oil mordant, often incorporating lead pigments as driers for the oil, and occasionally also vermilion and red and yellow earth to produce a slightly tinted effect which enhanced the tone of the gold. Also on raised decorative elements of the canopy, silver leaf was glazed with verdigris in an oil medium to produce a rich *translucida* effect.

Binding media

Analysis of the media is compromised by past conservation treatment; it is known, for example, that a wax 'preservative' was applied to the vault in 1927. However, analysis of carefully selected samples by FTIR indicated that glue may have been the medium for the gesso (calcium sulphate) ground, and oil or resin for the verdigris.

Relief decoration

The most striking aspect of the decoration of the chapel is the numerous elements in relief, particularly the stars and suns on the vault. These originally contained mirrors to reflect the candlelight, and have only one known parallel in England: a 15th-century ceiling in St Mary's Church, Bury St Edmunds (Suffolk).[14] Although mirrors were used as early as *ca*1260-70 in the nave vault of the lower church at Assisi, the Canterbury decoration is immediately reminiscent of the Chapel of the Holy Cross at Karlstejn, of similar date (second consecration, 1365), with its golden vault studded with glass stars.

The suns and stars are of complex construction, and were examined in detail by the Canterbury Cathedral Wallpainting Workshop during the recent conservation programme.[15] Evidence from close visual examination and from the samples taken, suggests that both motifs were made in a complex mould—one each for the suns and stars. A working hypothesis for the construction is that a convex glass disc – fragments of which remain on a small number of the motifs – was first inserted into the centre of the mould, silvered and then filled with a red lead mixture (not analysed). Tin leaf was then pressed into all other parts of the mould and, for the rays and adjoining decorative circles, a wax/resin mixture (not analysed but probably beeswax) was poured in.[16] Over the back of all this – and functioning to support the complex structure – a further layer of tin leaf was applied (a disc for the suns and a hexagon for the stars).[17] The whole structure would then have been adhered to the vault – when slightly warmed, it was possible to fit these appliqués to the curved shapes of the vault, and over the edges of the groins. Analysis of a sample taken from the edge of one of the rays suggests that they were very probably gilded,[18] and the tin leaf between the rays then painted in red to conform to the overall colour of the vault.[19] To mark the apex of the vault, four of the suns were joined together to produce an elaborate four-lobed design.

Further analysis is necessary to confirm this hypothesis and to clarify the constituents of raised red centres, the wax/resin rays and the type of adhesive used to adhere the structures to the vault.

The screens surrounding the chapel are decorated with numerous small attachments in gesso (calcium sulphate), in various designs such as: four trefoil headed motifs adjoined to form an elaborate scroll; and floral motifs with eight petals – each petal having a central disc and two outer lobes. FTIR analysis indicates that glue was used as the binding medium for these attachments. Ornaments very similar in design – though not yet analysed – occur on the wooden tester of the tomb of the Black Prince, in the choir of the cathedral, and elaborate gesso ornament is also a feature of other English tombs of the period.[20]

Other raised ornaments used on the screens of the chapel – with similar decorative motifs to those made of gesso described above – consist of red lead, sometimes combined with lead white. For these, it appears that an oil mordant was used to adhere them to the screens. On the western vault, a tiny raised ornament depicting the Agnus Dei also appears to be of red lead, but has not yet been analysed. Relief ornament in red and white lead was used extensively in the royal wall paintings of St. Stephen's Chapel, Westminster Palace (1351-63).[21]

Some of the most splendid decorative details were reserved for the canopy of the niche on the reredos, under which a statue of the Virgin was probably originally placed. Here, the whole stone structure was mordant gilded over a red lead and vermilion ground,[22] and, in imitation of real jewels, the canopy was studded with glass beads – two of which survive.[23] Such sumptuous decoration is highly reminiscent of Bohemian schemes of the period, such as that of St. Catherine's Chapel at Karlstejn, where semi-precious stones decorate the walls, and the eastern boss is decorated with jewels and an antique cameo.[24]

Acknowledgements

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Notes

1. Each of these cases studies has been published in full. For the Romanesque paintings in St. Gabriel's Chapel, Canterbury Cathedral see: Cather, S., & Howard, H. St. Gabriel's Chapel, Canterbury Cathedral: its technique, condition and environment reassessed. In: *Forschungsprojekt Wandmalerei-Schäden* (Arbeitshefte zur Denkmalpflege in Niedersachsen, 11) Hannover, 1994, 141-156. For the wall paintings in Winchester Cathedral see: Howard, H., Techniques of the Romanesque and Gothic wall paintings in the Holy Sepulchre Chapel, Winchester Cathedral. In: *Historical Painting Techniques, Materials and Studio Practice,* Preprints of a symposium, University of Leiden 26-29 June 1995, Getty Conservation Institute (1995) 91-104. For the Chapel Of Our Lady Undercroft, see: Howard, H., The Chapel of Our Lady Undercroft, Canterbury Cathedral, and the relationship of English and Bohemian painting techniques in the second half of the 14th century. *Technologia Artis,* **3** (1994): 31-34.
2. James, M. R., & Tristram, E.W. The Wall Paintings in Eton College Chapel and in the Lady Chapel of Winchester Cathedral. *Walpole Society,* **17** (1928-9): 40.
3. I am most grateful to Raymond White of the National Gallery, London for carrying out this instrumental analysis.
4. Hluvko, S. *Red Pigments in English Medieval Wall Painting*. Unpublished dissertation, Courtauld Institute of Art, 1991: 41-2.
5. Mairinger, F., & Schreiner, M. 1986. Deterioration and preservation of Carolingian and medieval wall paintings in the Müstair Convent. Part II: materials and rendering of the Carolingian wall paintings. In: *Case Studies in the Conservation of Stone and Wall Paintings*, ed. N.S. Brommelle *et al.* London: International Institute for the Conservation of Historic and Artistic Works, 196.
6. Pers. comm., M. Matteini 1990.
7. Park, D. 1983. The wall paintings of the Holy Sepulchre Chapel. In: *Medieval Art and Architecture at Winchester Cathedral*: British Archaeological Association Conference Transactions 1980. VI., 40.
8. Mairinger, F., & Schreiner, M. 1986, *op. cit.,* 195-196.
9. Ultramarine was the mineral blue normally employed in Romanesque wall paintings, though azurite has been identified at Kempley (See Rickerby, S. 1990. Kempley: a technical examination of the Romanesque wall paintings. In: *Early Medieval Wall Painting and Painted Sculpture in England*, ed. S. Cather *et al.* Oxford: BAR British Series 219, 256) and Mårslet, Denmark (Graebe, H., Trampedach, K., & Jensen, M. 1986. Kalkmalerierne i Mårslet Kirke. *National museete Arbejdsmark* 23:164-82).

10. For the will of the Black Prince (father of Richard II), with its detailed instructions for his burial in the chapel, see Harvey, J. 1976. *The Black Prince and his Age.* London 160-5.

11. Winfield, D. 1977. *The Cathedral of Christchurch, Canterbury: a report on the wall paintings.* (unpublished report: 6).

12. Analysis has shown that calcium sulphate salts, supplied by the original gesso ground, penetrated through the paint layer. When a wax coating was applied in 1927 it combined with the calcium sulphate salts to form the surface crust.

13. For this testing, carried out by T. Curteis, see Conservation of Wall Painting Department. *Chapel of Our Lady Undercroft, Canterbury Cathedral: report on cleaning tests on the vault and screen.* Unpublished report, Courtauld Institute of Art, 1990.

14. These are on the aisle ceiling above the monument of John Baret (d. 1467).

15. Possible method of build-up of suns from the Chapel of Our Lady Undercroft. Unpublished report, 1986.

16. Traces of tin leaf on the surface of the rays are likely to be the remains of the tin lining to the mould used to produce the motifs.

17. Cross-sections taken from one of the stars show that the upper part of the disc has oxidized to cassiterite (SnO_2), also known as wood-tin owing to its fibrous and granular appearance.

18. The raised moulded decoration used for the borders of garments and haloes on the wall paintings of *ca*1485 by Ghirlandaio in S. Maria Novella, Florence, are constructed of beeswax over which layers of first tin and then gold leaf have been applied—both adhered with an oil mordant. See Bandini *et al.* The restoration of Domenico Ghirlandaio's frescoes in the Cappella Maggiore of S. Maria Novella in Florence: problems, practical work, results. In: *Case Studies in the Conservation of Stone and Wall Paintings. Preprints of the contributions to the Bologna Congress, 21-26 September 1986.* IIC, London, 1986:186-7.

19. Canterbury Cathedral Wallpainting Workshop suggest that the suns were made in two parts: the mirrored centre was applied to the vault first, and over this the outer disc of rays and circular motif was adhered.

20. For example on the 14th-century tombs at Ingham; Howard, H. The scientific examination of the de Ingham and de Bois tombs at Ingham, Norfolk (forthcoming). A late 14th-century account of the production of gesso attachments is provided by Cennino Cennini (*The Craftsman's Handbook,* trans. D.V. Thompson, New Haven 1933 [reprinted New York 1960], 109-10).

21. Van Geersdaele, P. C., & Goldsworthy, L.J. The restoration of wall painting fragments from St. Stephen's Chapel, Westminster. *The Conservator,* 2 (1978) 11-12.

22. FTIR analysis of the medium of the red lead ground for the gilding indicated the presence of oil.

23. Two beads (one blue and one clear) and one blue disc survive (pers. comm., T. Organ).

24. *Die Parler und der Schöne Stil 1350-1400* (exhibition catalogue, Cologne 1973), Vol. 3: 174-5.

CASE STUDIES IN CONSERVATION OF *SECCO* WALL PAINTINGS IN NORTHWESTERN ITALY

Stefano PULGA

ABSTRACT

Northwestern Italy's wall paintings are very often executed ignoring *buonfresco* technique. Various types of the binders employed are examined in the paper. As continental climate may strongly affect such fragile paint layers, it has to be studied case by case. A complete study of the origins of dampness on the walls has to be carried out as well. The importance of resolving any problem linked to dispersed waters is discussed.

Four case studies are considered in the paper. Each of them posed a methodological problem to the restorer due to the techniques employed or the particular state of conservation. Laboratory tests were carried out prior to any restoration choice to define the intervention strategy.

Keywords: secco technique, binders, climate, weathering, soluble salts, ice growth, building survey, injection grouts, retouching options, laboratory tests.

INTRODUCTION

This paper will mostly focus on mural painting conservation in the Aosta Valley, even if comparisons can be made with the surrounding region's wall paintings, as the mural painting techniques described have been widely employed outside of Italy. From an artistic point of view, the main influences came to the Aosta Valley more from northern countries than from Italy. The *fresco* technique (*fresco*, Italian for 'fresh': i.e., wet plaster), the typical Italian wall painting, is not so widely represented. In only a few cases, some Italian painters, called by the rulers to decorate their main castles or churches, used the fresco technique, but the bulk of mural painting was executed by local painters on dry supports, as is done throughout the Alpine regions. In Italian, *secco* means 'dry,' which is why this term is used in the paper.

In fact, the Aosta Valley owes its peculiarity to its position in the Alpine region: it is encircled by the highest mountains in Europe; it borders on Switzerland (north), France (west and south-west), and Italy (south-east). Communications with Italy were very difficult: till 1930 the only way to go to the nearest Italian town, Turin, 100 km away, was the ancient Roman consular road, and a 30-hour journey was needed. This explains why the Aosta Valley has always been isolated from Italy, and the main trade and exchanges have occurred more through alpine passes like the Great St. Bernard (leading to Switzerland, to the Rhine basin and lower Germany) and the Small St. Bernard (leading to the Rhône basin and southern France and Spain) than towards Italy. With those French-speaking regions, relationships were close, albeit seasonal. Aosta's bishop ruled over some regions of France (Maurienne) and the first capital of the Savoy state, to which Aosta belonged, was Chambéry. Even now, the mother tongue of Aosta Valley's natives is an archaic French dialect, common to the surrounding valleys of Abondance (France) and Bagne (Switzerland). In this context it is understandable that artistic influences did not come from Italy, either.

SPECIFIC WEATHERING PROBLEMS OF SECCO WALL PAINTING

In a secco paint layer, the pigments have not been fixed by the carbonation of the lime, so its resistance depends on the strength and durability of the binder employed. In northwestern Italy's secco wall painting, the binders most commonly encountered are:

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- Lime, used to mix the pigments. Generally, if lime is used without fillers on a dry plaster, it is not very strong, due to quick dehydration, consequent dimensional shrinkage and poor carbonation. Lime paint layers are usually matte, adhering weakly to the underlying plaster.
- Calcium caseinate, an organic-inorganic compound (often incorrectly referred to as *casein*), which gives a very strong, glossy paint layer.
- Organic binders, such as egg-white or egg-yolk. Sugar-rich substances, such as beer, fig-tree milk, milk, honey. Animal glues, such as fish glue, rabbit-skin glue. Vegetable esters, such as garlic juice, rosemary oil. They give uneven results (except egg-yolk) and generally very weak binding. All these binders age poorly, due to pronounced water solubility and sensitivity to microbiological attacks.
- Oily binders, giving strong, glossy paint layers. Usually the fatty medium is mixed with lead white; both oil and lead are easily identified with infrared spectrophotometry.

If one has to deal with secco wall painting conservation, it is of the utmost importance to know the surrounding climate. Generally a one-year period of measurement is needed to monitor tendencies in the weather and identify the specific microclimate around paintings. Prior to any intervention, it is also of great importance to survey the state of roofs and rainwater disposal in order to keep water away from the walls. A great amount of the dampness present on walls is usually due to faulty guttering or drains. As ancient monuments nowadays often lie lower than modern streets, it is easy for rainwater to reach the foundations directly. In this case digging drains is essential to prevent capillary rise inside the walls of the monument. A very accurate survey is essential to know the building, its problems and its behaviour when exposed to common and less common meteorological events.

CLIMATE

Some measurements, made in a 16th-century cloister where painted stone and mural paintings are in outdoor conditions, are studied here. The continental climate has wide fluctuations between summer and winter, and it is more dangerous than a temperate climate, which is exempt from extremes in temperature and RH changes. The continental climate is widespread in Europe, and the measurements shown could have been taken in many European regions other than the Alps.

In the Alps, as might be expected, the weather in winter is cold and snowy; more surprisingly, summer temperatures can reach very high values (up to 36°C) and humidity is generally very low. Thermal and RH excursions can be very important, as measurements in the accompanying diagrams show:

Summer. Very strong cyclic variations are noticeable. Sawtooth lines indicate daily variations of more than 15°C. RH variations are even more dramatic. As we can see, after an evening summer rain (day 13), RH reaches dew point at dawn, to fall very quickly after sunrise. RH goes from 95% to 30% in less than 4 hours (day 14).

Autumn. Temperature variations become less important. Rainy days are marked by high RH and low thermal variation. After rainy periods, cold, dry gusts often occur (days 19 and 20), considerably lowering the absolute humidity (AH).

Winter. More than 15 dangerous freeze-thaw cycles can be noted in a typical winter diagram (February). Snowfalls are common (days 6, 8, 10, 11), and are often followed by strong, dry, warm winds, called föhn (days 7, 10, temperature peaks). In these cases, thermal variations increase, and large RH fluctuations are recorded daily.

Spring. Thermal variations intensify, rainfall is again followed by warm, dry periods with severe RH changes, as can be noticed in these sequences:

- day 5, 12:00, RH 38% to day 6, 06:00, RH 90%
- day 14, 01:00, RH 21% to day 15, 09:00, RH 90%
- day 15, 09:00, RH 90% to day 16, 15:00, RH 26%

Conclusions on climate

Continental climate has temperature extremes between summer and winter that can be very dangerous. The surface temperature of a grey stone of a monument showed extremes of -26°C in late January and + 57°C in early August (when hit by direct sunshine): the total variation was thus 83°C. Building materials are in this way stressed by dimensional changes with an annual cycle. Sudden variations cause severe variations in RH and may start strong evaporation. Crystallization of soluble salts occurs inside the porous building materials, due to the high evaporation rate. In winter, the frost point can move inside the building material, causing ice crystal growth. For all these reasons, water should be kept away from monuments; otherwise

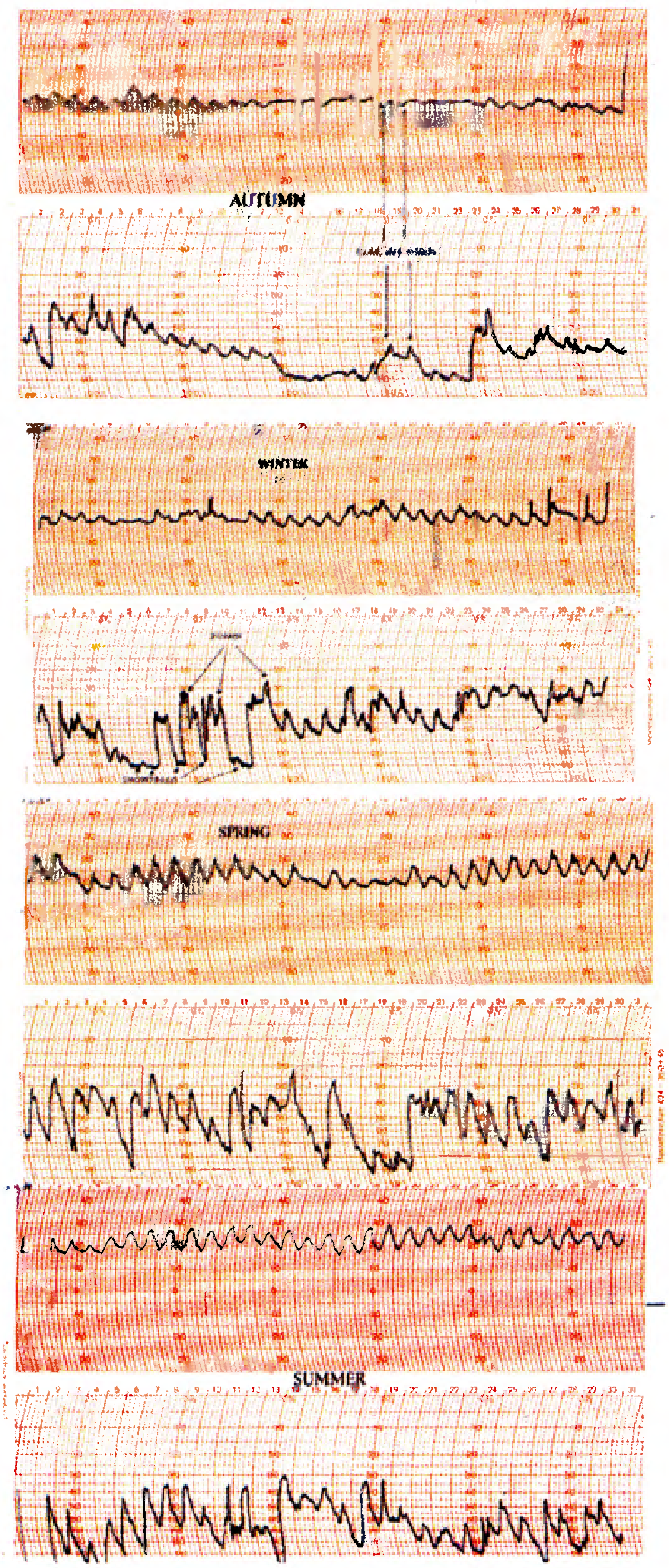

Figure 1. Thermohygrometric charts illustrating the discussion in the section on climate.

any restoration project will quickly fail. In such a climate, salt crystallization and ice formation are very likely and will produce destruction of paint layers and porous materials if not avoided. Climatic changes are obviously less dramatic indoors. It is, however, essential to realize that an internal mural painting is merely the 'other side' of a wall undergoing severe climatic stresses and important humidity variations.

Only with knowledge of the climatic conditions surrounding a painting can some essential, albeit elementary, decisions be taken to avoid further damage. Every intervention on the climate has to be planned and decided on a scientific basis: 'opening the windows' in spring to dry the air inside a painted room, or occasional heating in winter may produce destructive effects. On the basis of the measurements made, it can be assessed that an occasional heating in winter, when RH and AH are very low, may cause further drying of paint layer and harmful convection currents. In late spring, warm, wet air coming from outside can cause condensation on the still relatively cold walls. This is the period of the year in which, paradoxically, a monument should be gently heated.

CASE STUDIES

General Problems

Churches and castles are the typical monuments of the Aosta Valley. Very often they have wall paintings, both inside and out. External painted plasters are exposed to direct sunlight, which enhances the thermal variations, causing repeated dimensional stresses as well as vapour migration. Operating on wall plasters exposed to such severe climatic conditions requires a careful choice of the materials to be used. If some loose zones need to be filled to restore continuity between the plaster and the wall, two elements seem very important to me in determining the choice: a) dimensional behaviour, which has to be as close as possible to that of the ancient mortar; and, b) vapour permeability, which has to be the highest possible. If a bad choice is made, the result – under repeated dimensional stresses and vapour migration – will always be the detachment of the injection material from the support – the exact opposite of what was wanted. So, one has to avoid polymers or anything reducing vapour permeability when preparing an injection material. On the other hand, a sampling of the composition of the original plaster can help to choose the filler for the injection grout (e.g., brick powder, mica, marble powder, etc.) in order to have similar mineralogical characteristics. It is very important to realize that the products to be injected may perform excellently in the laboratory, but one has to look at their real behaviour when used on ancient materials. The 'best glue' tested in the laboratory may prove to be merely unsuitable when in contact with a powdering, weak plaster. In general, materials that are too strong, too hard or too compact should be avoided.

The Church of Santa Maria in Villeneuve. Retouching: How and How Much?

History. This 12th-century church received important modifications in the middle of the 16th century. The vaults replaced the former wooden carpentry and were painted in 1535. The painting, very crude, is based on the iconography of one of Aosta's main churches (Sant'Orso), on which Villeneuve depended. Arches and vaults were painted on a dry plaster; the pigments were bound with a very weak glue of vegetable origin. The paint layer must have been flaking and powdering almost since its completion. Where water infiltration occurred, no paint layer was left. Important decay occurred in the 17th century, when a lack of maintenance and very heavy snowfalls caused the eastern part of the roof to collapse: all the painted plasters of the western bay and choir were lost and replaced with a new, unpainted rendering that also covered the walls. Late in the 18th century, a new church was built in the village; it was much easier to reach, especially in winter, and this caused the demise of any maintenance programme. In 1968, a survey noted impressive cracks in the vaults and water infiltration from roofs and foundations. A recovery programme began in the same year, with structural consolidation and new roofs. Archaeological digs uncovered the remains of two former early-Christian buildings and a baptistery (5th to 9th centuries). Investigations on the walls that led to mural painting discovery started in 1984. Restoration programmes on the clock tower, the inner plasters and mural paintings were executed in 1988-1995.

Painting Technique. The prophet's portraits were painted on dry *intonaco* after a laborious preparatory drawing. On the plaster, sharp-edged incisions are clearly visible, proof of the dryness of the plaster when they were executed. After having traced the main guidelines, the painter limewashed the surface of the wall and painted with a brush and black pigment the outlines of the prophet on the freshly applied lime coat. This produced a slight carbonation of the preparatory drawing. The colours were applied later with a vegetable binder.

Figure 2. Church of Santa Maria, Villeneuve. One of the prophets (Malachi) on the arch band: note the powdering paint layer and, on the sides, the complete loss of the frieze's paint layer where water infiltration occurred.

Figure 3. Church of Santa Maria, Villeneuve. The lower parts of arches and vaults suffered extensive water infiltration. The various types of paint layer losses discussed in the text can be seen.

Decorations of the arches were based on a pattern (*cartone*) that has been easily identified and later used to reconstruct lost parts. The painting was executed on a completely dry plaster that had been carefully smoothed while setting and has a very even, glassy, surface.

Cleaning. Cleaning such a weak paint layer is a terrible experience for the restorer. The weakness and water solubility of the paint layer forbid the use of common cleaning techniques, either chemical (ammonium carbonate poultices) or mechanical (rubber or bread rolling, Wishab sponges).

After some cleaning tests, the solution eventually adopted was to gently roll a cotton swab with a mixture of:

- isopropanol, 1 part
- ammonia (sp. gr. 28 Baumé), 1 part
- acetone, 1 part

The compound has a low polarity (solubility parameters: fH=35, fP=23, fD=31) and gently softens the binder. As the swab is rolled over the surface, the paint flakes can be pressed and stuck back on the plaster surface while being cleaned at the same time. The main inconvenience of this system is that the whole operation must be done in a single passage: any return over the "wet" surface will produce a loss. If further cleaning was needed, it was done the next day. In spite of these difficulties, cleaning results were sound and hardly any losses occurred.

Consolidation. The cleaned, dry paint layer was consolidated by spraying Paraloid B-72 2.5% (W/v) in 1.1.1 trichloroethane with an airless spray gun. This choice was made after other consolidation methods failed. On the very compact plaster surface, the other materials tested produced bright films. Water-based consolidants could not be used and no brush application was possible.

Weak zones of the plaster were consolidated with injections of Wacker Steinfestiger OH, diluted 3:1 with acetone. Loose plaster was stuck back on

Figure 4. Same view as 3, after restoration. The integration of the brown background frieze has been carried out without any attempt to reconstruct the free-hand painted scrolls. In contrast, the pattern-based decoration of the arch permitted completion of lacking elements with flush filling and 'tratteggio' technique.

the walls with injecting grouts based on slaked lime, marble powder and brick powder in equal parts.

Classification of Paint Layer Losses. Classification of losses in the paint layer was crucial in defining the kind of aesthetic presentation to be achieved. The main paint layer losses were located on the lower parts of vaults and arches, due to ancient water leaks from roofs. These whitish parts contrasted strongly with the surrounding paintings of high hue and saturation. The losses were eventually divided into four categories:

A) loss of flakes

B) complete loss of painted plaster in a pattern-based decorated zone

C) complete loss of painted plaster in a free-hand decorated zone

D) complete loss of paint layer, with the original plaster still present.

Retouching Choices. Bearing in mind aesthetic balance and restoration ethics, it was decided to retouch the losses following this scheme:

- type A losses: glazes of watercolour to lower the luminosity of the loss without reaching the same saturation as the original colour;
- type B losses: flush lime/marble powder fill; pattern-based reproduction of the lost part with tratteggio technique;
- type C losses: new lime/sand plaster fill, 1 mm under level; retouched with tratteggio reproducing the background colour without the decoration;
- type D losses: watercolour glaze of the original background colour with lighter tones.

In this way, the original paint layer and the retouched parts are still easily distinguished, but less apparent than the crude losses.

San Grato Chapel: An Extreme of Conservation Imbalance.

History. This 15th-century chapel was used from 1720 as a fire brigade depot, and from 1880 as a wholesale store. In the early 20th century, it was internally divided in half by a floor, to gain space. The floor beams were deeply embedded in the southern wall. At this stage, the walls' lower parts were hammered to key in a 5 cm layer of gypsum. On the outside façade, roofing was installed to shelter the customers entering or simply window shopping. Unhappily, at that time nobody knew or

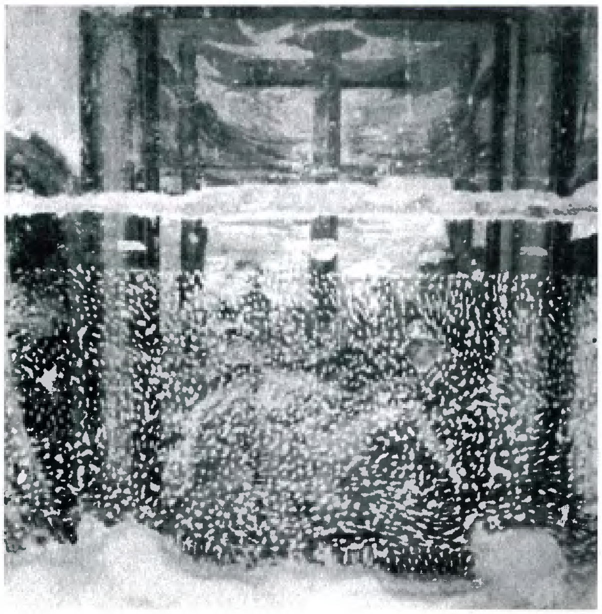

Figure 5. San Grato Chapel. Interior painting after the removal of superposed paint layers and plasters.

remembered that the façade and the inner walls had been painted. Only in 1988 were further investigations made on the stratigraphy of the walls, showing evidence of painted surfaces.

Interior Paintings. After the removal of the floor and the gypsum plaster, the mural paintings were still covered by two limewashes. These were removed with scalpels. The interior painting, belonging probably to the late 17th century, showed major differences in conservation between the upper and lower parts. This was due to the different techniques used while painting the wall. The painter started in the upper part, applying a new lime plaster on the existing one, as if he would proceed to a fresco painting. The painter waited for the plaster to be hard enough to draw a preparatory

Figure 6. San Grato Chapel. Interior painting after filling of pick holes and retouching tests.

sketch with a lead pencil. He then painted the upper part with a weak binder on the still slightly wet plaster. As the result did not satisfy the painter, for the lower part he changed his technique, choosing a stronger binder (calcium caseinate), but *still working on an incompletely dry plaster.* This shows both a complete ignorance of traditional wall painting techniques and improvisation to achieve the work. Improvisation is also indicated by radical compositional changes in the lower part. There is, in fact, a first composition incised from a cartoon on wet plaster. The actual composition is quite different and has been sketched later on dryer plaster with a lead pencil. The result of such an unsure technique is a mural painting with marked differences between lower and upper parts in gloss and luminosity. These differences were accentuated by the aforesaid interventions (floor, keying of plaster) which, almost unbelievably, nearly coincided with the existing limit between the two techniques. In the lower part, heavily hammered, the calcium-caseinate based paint layer adhered irregularly to the wall, extensive zones had flaked and others were lost. In the upper part, the paint layer had numerous spots, leaving the underlying plaster uncovered. The exfoliated flakes were re-adhered to the plaster operating through Japanese paper with a borax caseinate solution. The cleaning was done with the same compound as that used in Villeneuve.

It was decided to fill the pick holes and to retouch them with tratteggio technique in order to give the painting a chance to be understandable again. In my opinion, this kind of intervention **must** be supported by complete documentation and explanatory drawings, permanently on show to allow recognition of the extent of the retouching and the problems met.

Exterior Paintings. Outside, on the façade, a 15th-century, calcium-caseinate bound, very strong paint layer was uncovered with scalpels. It was dulled by several animal glue coatings, probably used at some stage to 'refresh' the colour. The animal glue had become dark and irregularly insoluble. Some glue could not be removed with repeated warm water application [a test was made with acidulated water (5% acetic acid) with no result], and had to be removed by micro-sandblasting. Crushed walnut shells (250 mesh) were sprayed at 0.8 bar through a 0.6 mm hose; the work was very slow but the paint layer was respected. In any event, it must be noted that micro-sandblasting units can be very dangerous tools in inexperienced hands. The main losses to the paint layer were due to the above-mentioned mounting of a roof through the almost-invisible painted plaster and to electrical work. After cleaning, the retouching was minimal and was done with watercolour glazes. Tratteggio was used only on some losses on the painted frame.

A Private Chapel in Aosta Cathedral

In this case, a 16th-century funeral chapel, with calcium caseinate painting on the vaults, had been overpainted by two layers of whitewash and one layer of vinylic wall paint. The paint layer was uncovered with scalpels. Smoky deposits were removed with a 3-minute application of AB-57 through Japanese paper. The paint layer was strong, bright and relatively glossy. The gilding had to be cleaned separately without using any water. Losses were due to salt crystallization because of roof leaks; otherwise the paint layer was in mint condition. Retouching was minimal: watercolour glazes were used on losses. Tratteggio was used only on the wide crack running through the vault after an earthquake in the early 20th century.

LABORATORY TESTS

Laboratory tests are of the greatest importance in defining guidelines for the intervention and in understanding the painting technique.

The most commonly used investigations are: optical microscopy, infrared spectrophotometry and micro-chemical analysis.

Optical microscopy can provide important information about the number and nature of layers and pigments. Cross-sections can be observed under visible light, polarized light and UV light in order to better differentiate the nature of pigments and the succession of coats.

Infrared spectrophotometry helps in determining the main chemical components forming a layer.

Protein analysis helps to state the presence (or absence) of proteic binding media. This is of the greatest importance in choosing the cleaning method and in avoiding undesired dissolution of the paint layer.

It is of primary importance to register the place of sampling and the problem to solve. Sampling and laboratory tests ought to be done before any important decision about cleaning is made.

CONCLUSIONS

If a *buonfresco* wall painting can always (or almost always) be cleaned in the same way adapting only the cleaning time, secco wall paintings show so many variations of binders that the consolidation

Figure 7. San Grato Chapel, Aosta. Paintings on the façade. Fragment of Virgin and Child after the removal of the superimposed paint layers. Note the darkening of animal glue layers (see discussion in text) and the presence of a preparatory drawing under the painted intonaco.

Figure 8. San Grato Chapel, Aosta. Paintings on the façade. Same view after cleaning. The plaster losses are here integrated 2 mm under level with lime mortar.

and cleaning techniques must be studied case by case. Secco paint layers can be extremely weak and easily water-soluble, so it is important to have scientific support before starting any cleaning test programme. In the Aosta Valley, restorers have the scientific support of the Regional Chemical Laboratory, whose field of action is specifically the conservation of cultural heritage.

After fifteen years of experience on such problems, I suggest that every element (climatic, chemical and physical) that can affect the mural painting's life expectancy be thoroughly investigated. Decay factors act more dramatically on secco paint layers, so the greatest care is needed in preserving secco wall paintings from rising damp or leaking roofs. What should be done before any intervention on paint layers is, in fact, preventive conservation. I also think that it is a technical, ethical and deontic 'must' to intervene on the surroundings of the monument **prior** to any intervention **on** or **inside** the monument itself.

ACKNOWLEDGEMENTS

Thanks to Lorenzo Appolonia, head of the Regional Chemical Laboratory of Aosta Valley, for providing thorough scientific support in these projects.

Thanks also to Vinicio Furlan and Renato Pancella, Laboratoire de Conservation de la Pierre, Ecole polytechnique fédérale, Lausanne, Switzerland, for other microscope slides and their ready availability to discuss conservation problems since I met them in 1980.

Figure 9. Same view after retouching. Integration was carried out with watercolour glazes except on the nail holes, where flush filling and tratteggio were used.

THE CHURCH OF THE SAVIOUR IN POLOTSK IN A STRANGE LIGHT

PRELIMINARY RESULTS

Vladimir RAKITSKY

ABSTRACT

Everybody knew that ancient church, erected in the middle of the 12th century. It still stands in the same place. Everybody was also aware of its ancient painting in the Byzantine style, which had been seen through the 'dust of centuries.' One knew but forgot or did not see, did not notice when from time to time someone re-painted the wall or wrote symbols or letters again and again.

Perhaps it is a virtue of the human eye: to see and not to notice. However, all of the walls of the church of the Saviour in Polotsk have collected, absorbed and now keep the traces of many generations; these traces look like the pages of a book you want to look at, read and comprehend. But when starting on research, an investigator is faced with a problem. Initially he has to choose a universal instrument to help him differentiate and understand the information of those pages. What kind of instrument would that be? A scalpel, a microscope, a computer? Certainly they are useful, but first of all, an eye, the naked eye of the investigator is needed.

'*What is the most difficult*?' asked Goethe, '*It is that that seems the easiest to see, something that is in front of your eyes.*'

DRAWING WITH 'BOUND EYES'

The first and unexpected task for every new member of our restoration team is to draw two pictures. After observing the Church of the Saviour in the Euphrosine Convent in Polotsk, the person must draw the floor plan and the section of the church while standing with one's back to it. These first pictures look amusing because of their ingenuousness, as they are drawn in a sort of 'blindfold' manner. The person almost doesn't know what to draw. He has to recall things he saw some time before. But anyway, the images look unusually righteous, although they look more like their authors than the object.

The second task allows the person to come inside the object or to walk around (as before, one has only 10-15 minutes). In this case, everybody begins to count and measure everything with his/her hands and feet. They count pillars, naves, windows, even chairs, but to our surprise, when one has an opportunity to see everything with 'unbound eyes' the images become fragmentary and helpless.

There is no point in speaking about giving preference to one of these methods because each of them states different angles of the vision of the object – a vision of the whole object or a separate detail. And, at first sight, these two methods represent different and even opposite systems or techniques of perception.

"OGNI PITTORE DIPINGE SE"

I wonder how previous generations saw and drew the same church. To start with, nobody drew it until the beginning of the 19th century because nobody saw it. The fact is strange and even revolting. But the same could be said about the Acropolis, the citadel of Athens. It did not seem to exist.

Usually the church drew some attention at times when the king changed, or there were invasions, or expansions. New leaders brought new vision. New maps and laws appeared stating what to preserve and what to remove. We have a law of that kind and the draft of the reconstruction/ restoration for our church worked out by the royal Russian architect, A. Porto, in 1833. And we have

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Sighisoara, Romania, 31 August-3 September 1995

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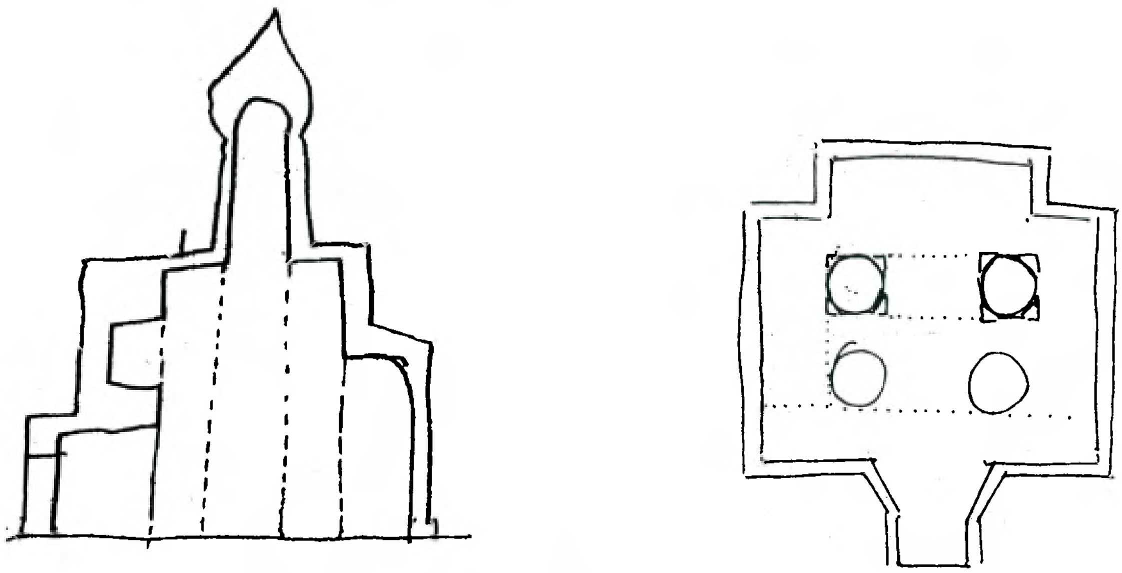

Figure 1. The section and plan of the church were reproduced by an artist standing with his back to the church. Needless to say, it does not reflect the object itself, but the knowledge of it. Imagination and eyes hold and see the object as a whole.

his instruction '*to preserve the interior and the exterior as it is. To save the painting on the walls inviolate.*'

Yet, on scrutinizing his project, we can see that the architect himself did not follow his own instructions – his project stipulated changes of the fronts, attaching a belfry and adding features in the style of Le Duc.

The next researcher, an academician of 19th-century architecture, asserted that A. Porto had significantly changed the proportions, and that the drum and the head of the church had been lower. He suggested returning to the 'correct' Byzantine proportions. It's no problem to infer that the pseudo-Byzantine style was popular at that time. And the bulk of the churches of that time were erected in that style, and some of them near the Saviour church. What can explain the academician's mistake? Was he unwilling to study the object itself, or was he merely advocating his own conception of architecture?

Until now the proportions of the Church of the Saviour in drawings by different investigators have been either narrower or longer, regardless of the fact that the church itself is still in the same

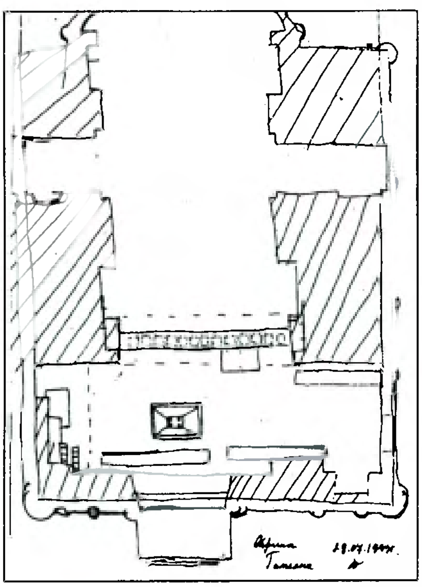

Figure 2. The same church draft, but reproduced from inside the building. In that case the piece of paper was not enough to contain all the details seen.

Figure 3. The Church of the Saviour in Polotsk. Plan of the upper tier, 1994.

Figure 4. In 1833, A. Porto, the architect, could not preserve the original look of the fronts, despite his own instructions, during restoration of the Church of the Saviour. It is clear on the draft that the architect used original elements of window frames for a new belfry, which was not erected. But the new raised cornice and the roof did protect the ancient church from further destruction.

place. It is true that it is not the object that speaks, but the subject.

Now we begin to measure. And only with the help of numbers can our eye put everything in its place and set the norms. Everybody knows the joy of creating a drawing with reliable measurements and figures. The fact of creating an object on the surface of the paper, the difference between the new drawing and our former impression, the emotion of discovering a new vision of the habitual, mental image. We have never seen the church in that light before, although we have visited or walked past it for many years.

ALPHABET

In the beginning of his *Die Kunstgeschichtlichen Grundbegriffe*, Heinrich Wölflin relates the experiment that Ludwig Richter performed in Tivoli. Four artists agreed to draw what they were looking at as precisely as possible. And it boiled down to the following, well-known result: four absolutely different pictures.

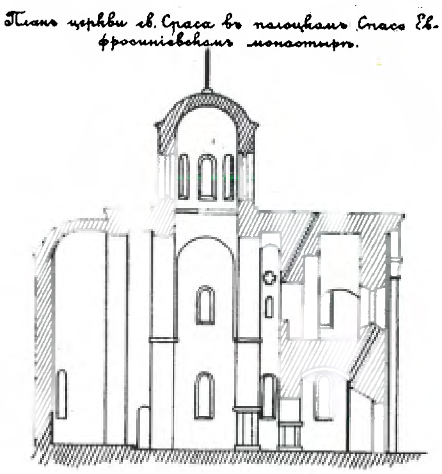

Figure 5. The drawing of the church published by the academician of architecture at the end of the 19th century. Notable for its cut down proportions.

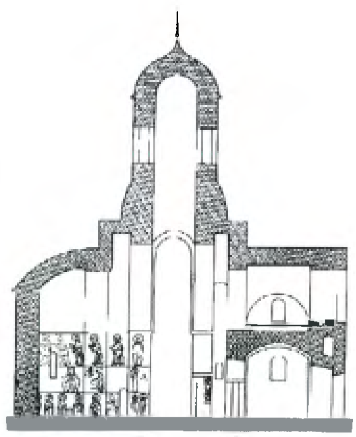

Figure 6. A drawing of the same church, published in 1988, expresses unjustified diffusion of proportions.

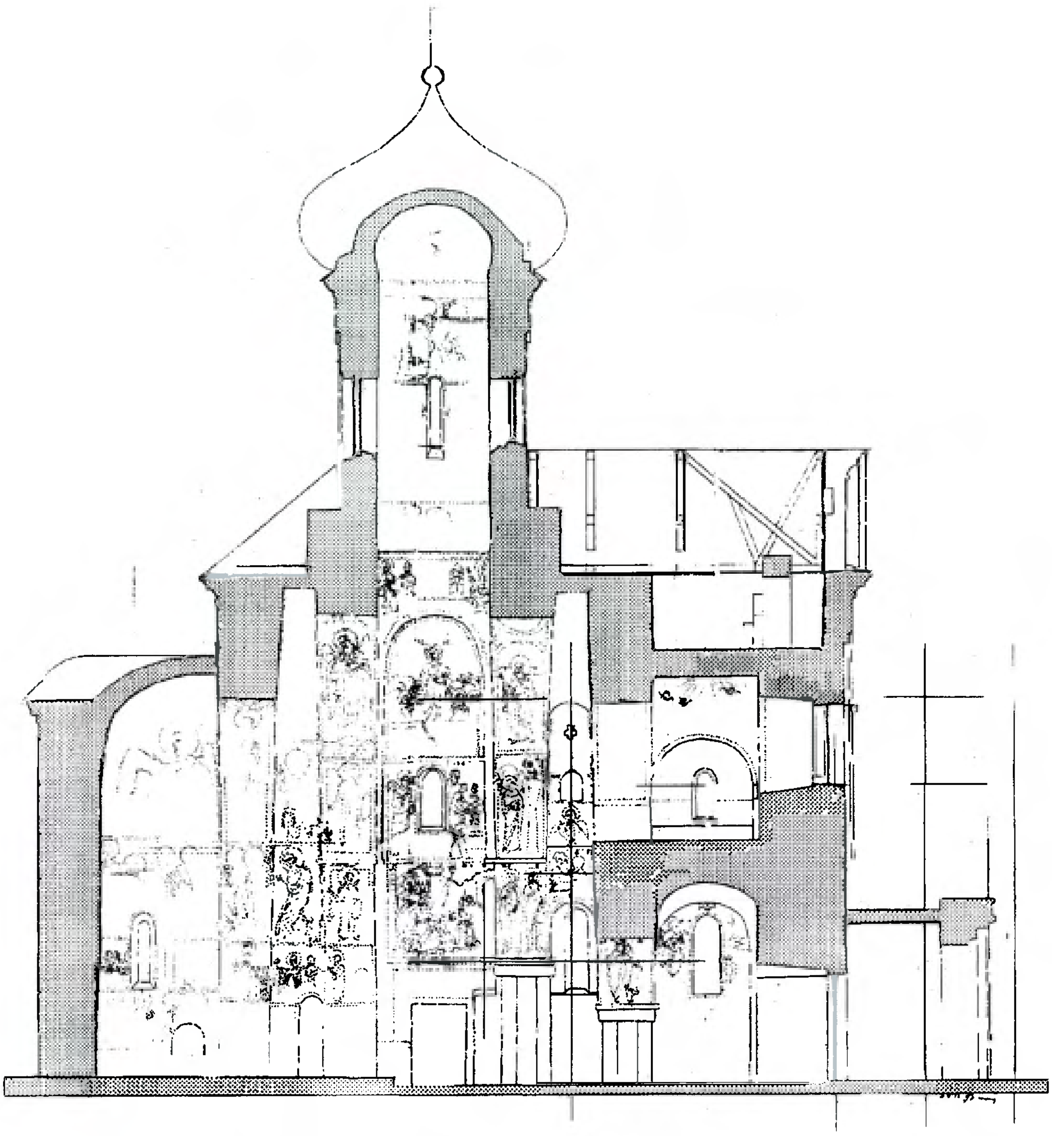

Figure 7. Measured drawing of the Church of the Saviour; section with wall paintings before the restoration. 1994.

We were stuck with the same kind of problem: How to reproduce in graphic form the information that has been preserved on the medieval wall? To begin with, we decide to repeat Richter's experiment. But there we tried to limit our means to a minimum.

For this purpose we did not take a landscape or an image on the wall, but a 'graffito' with distinct traits of every letter. Each participant had the task of not just reproducing but simply copying on transparent paper everything within an area of 100 x 100 cm. The first result, of course, was not unexpected: even with a mechanical transfer, the individuality of each participant could be seen and revealed: everyone saw something that someone else did not see.

And only after having stated the measurements and defined everything and agreed on one point, so only after all that did we get some kind of objective picture of the area in question. We also noted that the angle of view between the researcher and the object should always be changed, the vision should be corrected, the distance and time periods should be different; leave from one time of history and approach another. And the most critical thing was that the difference between the relevant and the irrelevant depends on the interests of a certain moment. Moreover, the principle and direction of the experiment depends on the interests of a certain moment.

On the other hand, we noticed that a word or a sentence, which had been read and comprehended as a whole, i.e., different things that had been seen altogether, could be easily translated to the graphic language.

And incomprehensible things remain incomprehensible. But one colleague and I found some big letters scratched on the wall, when

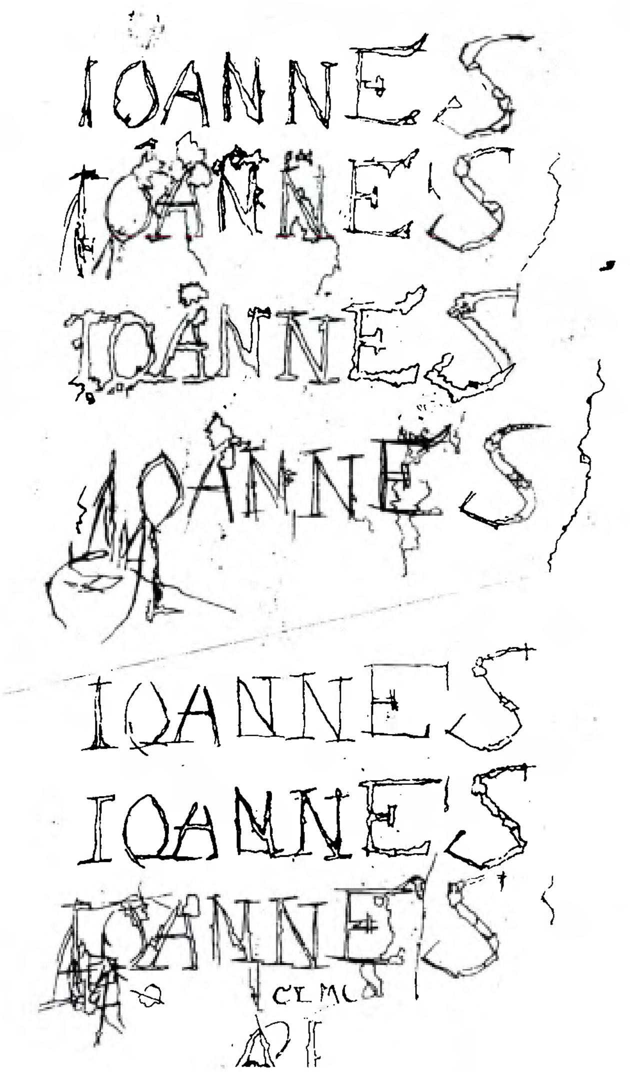

Figure 8. Probably, the differences in graphic reproduction of a concrete fragment by various artists could be explained by 'the interest of the given moment.'

looking at it in a raking light. Having in mind the rule of 'notionability,' comprehension of all the things that I see, what is in front of my eyes, I tried my best to start to read the whole word. Like a junior schoolboy, I moved my lips, read the letters aloud trying to make out a word, but it was in vain. I changed the light, the angle of view, but I could not put the 9 cm letters into a word. And here my colleague behind me said: 'Don't guess the word. They are just separate letters. Every letter is on its own. They are the first five letters of the Slavic alphabet!'

THE SOLITUDE

All the lower levels of the Saviour church and especially the temple of Euphrosine have been turned into painted pages by many generations, where every piece of the manuscript is an extract of a separate period of time.

For the writer, it was very important not to pay attention to what was around. One can explain that similar misunderstandings took place over many centuries. But how can one explain the fact when your own eye cannot see what you did with your own hands yesterday or an hour ago? The manuscripts of Leonardo da Vinci are one good example of this effect.

Nowadays we tend to look like those researchers who try to expound and set in order 'these odd manuscripts' each in his own way. They use different approaches. They try either to decompose and systematize a fragment from the books on a subject basis; or to read the manuscript page as it is, as the poet Paul Valeri did. But what is it to decompose the order of a day from the

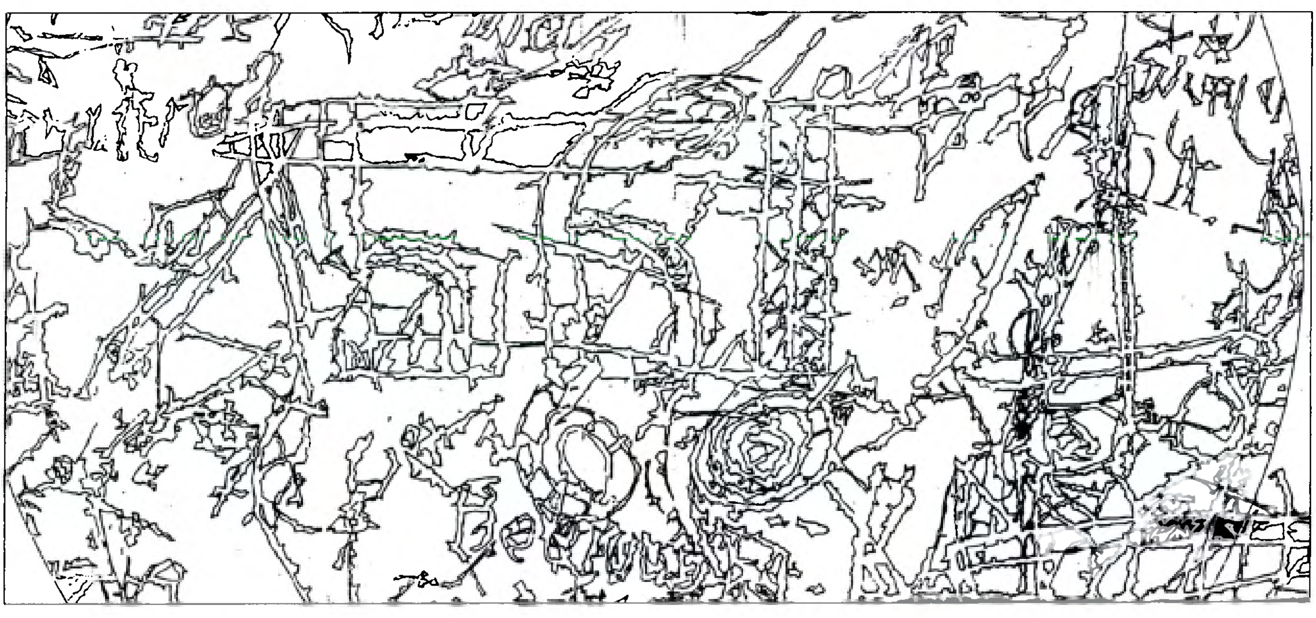

Figure 9. The first letters of the Slavic alphabet , which I was unable to make up into a word .

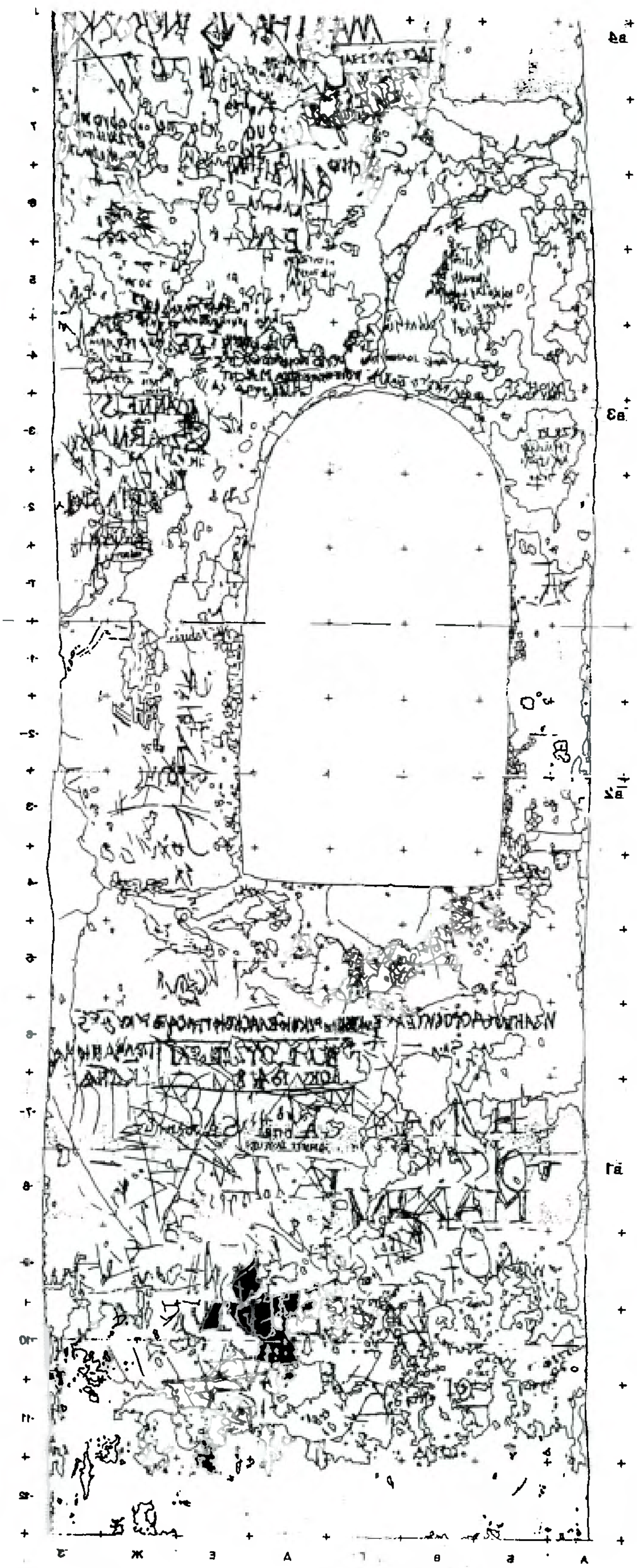

Figure 10. Part of a Euphrosine cell wall, translated into the graphic language.

lifetime of a wonderful person? What does it mean to put the notes and drawings of Leonardo in this or that order? It does mean to destroy the order of Leonardo da Vinci's page.

Yet, Leonardo himself appealed: *Read me, Reader, if I can please you because that happens extremely rarely in this world. Because not many have the patience to expound that kind of thing in their way.* (CM I, f. 6r)

We feel some sort of kinship between Leonardo's manuscripts and the fragments of the medieval wall of the Saviour Church in Polotsk. Even the fact of invisibility or unawareness of what we are looking at, i.e., the moment of quiet and getting-away-from-it-all solitude. Because in spite of the author – either a scholar or a pilgrim – they were written in a state of solitude, when a writer gave an outlet to his feelings and exposed them in scratches on the wall, whether it was a request, a cry, an event or just a name and a date. And each of these 'graffiti' appeals: 'Read me, Reader! I existed too.'

Separate moments of solitude today compound our knowledge of that time.

DRAWING HANDS IN A RAKING LIGHT

'The eye must go round the picture in the way the mind can comprehend what is said between lines/beyond it,' anticipates a medieval artist.

We will follow this advice and use lateral light against the medieval paintings, the fragments of which we have read. And then we will see some barely perceptible lines scratched over the new stratum of intonaco. Of course, that is a draft picture for *buon fresco*. But traditionally a preparatory drawing was made to outline a nimbus or tucks of tunics. In that case the lines have little in common with the shapes of the image. The originality of those chaotic lines is obvious, all of them were made over the fresh stratum and filled with paint.

Analyzing the whimsical lines, one sometimes has the feeling that the master held a bunch of straw in his left hand, his unskillful hand, and outlined his next move on the fresh surface, sometimes with the help of fingers. And we suppose that his left, 'blind' hand only just marked the shapes of the image as if guessing and not measuring it. The right hand with a brush and paint created a transparent film of another shape. But the fresh stratum of the intonaco has preserved both stages of creativity: relief and clumsy lines made with the left hand to roughly outline the shape and at the same time to ruin it, and thin and transparent

Figure 11. Detail of Euphrosine cell wall.

lines made with the right hand to restore it to life and create it. That pulsing duality is constantly in front of your eyes. But could a medieval pilgrim notice that? Could he see the lines with his eyes or comprehend with his mind? Or probably these lines provoked him to make some scratches on his own behalf, didn't they?

Why does the heart beat? Because the time to leave for a long-expected trip has come. And not because of the curiosity to look into a well of the unknown but also because of the fear of the alive\existing, while the alive is veiled with a safe cloth of mystery. And probably it was not wise to discover the Acropolis's rock which was hidden from eyes in the classic epoch. And today, looking at the hands of a saint martyr drawn on the wall of the Saviour Church in Polotsk which are seen under the dust and ashes of ages, you ask yourself: 'Do they appeal to take off the dark curtain or push us aside as if saying: *Noli me tangere*!'

Figure 12. Detail of the medieval fresco in a raking light, showing the characteristic of the incised preparatory drawing.

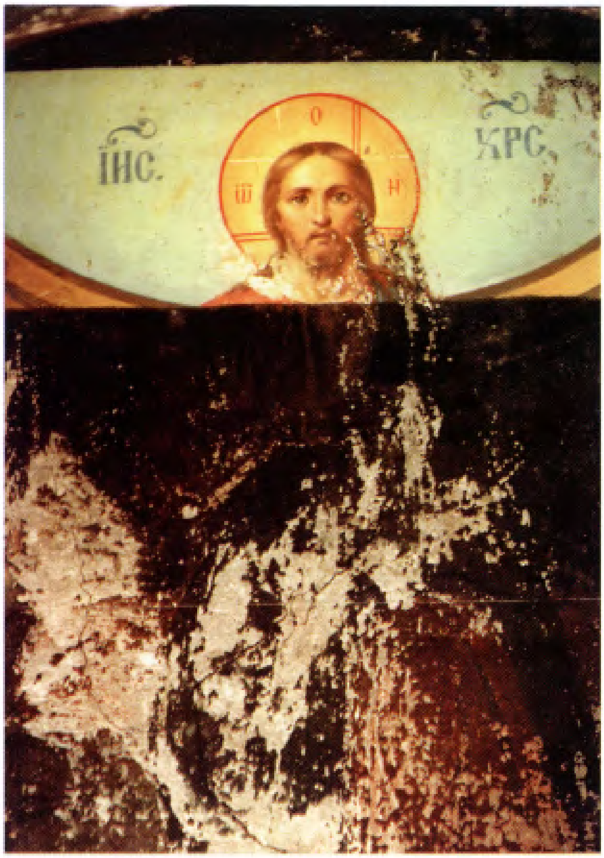

Figure 13. The condition of the 19th-century oil painting, which was detached and transferred to a new support before restoration of the medieval painting beneath it.

Figure 14. Detail of the image of Christ after removal of the oil painting (Fig. 13) which had covered it.

THE PRESENT STATE OF THE ANALYSIS OF THE MURAL PAINTING ON THE NORTHERN WALL OF THE HOLY-GHOST HOSPITAL IN LÜBECK

Jochen SEEBACH
Translation by Thomas SCHMIDT

ABSTRACT

Report on a research project of the German Federal Ministry of Science and Technology. The report first recapitulates the earlier measures taken. The condition encountered at the beginning of the research project is presented, as well as the examinations carried out and their results. All the relevant examinations were done, from simple ones like collecting the particles trickling down up to the application of high-tech methods provided by a mobile laboratory. In addition to the usual examinations of binding media, salt content and microbiological contamination, the climate close to the mural was also measured. In the course of four years, 31 measuring campaigns were carried out to determine the surface conductivity at fixed points. During these years, considerable changes at identical points were observed. Measurements of surface conductivity showed very good correlation with the results of the salt analyses and the close-range climate measurements.
These extensive examinations have yielded important insights for the forthcoming restoration.

Keywords: secco technique, binders, climate, weathering, soluble salts, ice growth, building survey, injection grouts, retouching options, laboratory tests.

The research projects of the Federal Ministry of Science and Technology concerning the preservation of monuments

In 1983, the German National Committee for the Preservation of Monuments urgently appealed to the public and those in charge to take effective measures against the decay of many important buildings and works of art. The federal government responded to this appeal. Through the Federal Ministry of Science and Technology it has, since 1985, been promoting research to investigate the causes of the various kinds of damage. This has included the following focal points:

- soil stability and structural stability
- buildings with natural stone walls
- buildings with brick walls
- preservation of historic mural paintings
- glass windows and glass paintings, and
- framework constructions.

One of these research projects, managed by the Fachhochschule Köln, was an investigation into the causes for the various kinds of damage suffered by the mural painting of the Holy-Ghost Hospital in Lübeck.

History of the mural

The Holy-Ghost mural dates from the first third of the 14th century. Its interpretation is still controversial. The few existing documents call it "the Throne of the Virgin Mary," "the Throne of Solomon," "the Messianic Wedding," or "the Apotheosis of the Virgin Mary." In this report, it will be called the "Throne of Solomon." This question should be settled by art historians, if possible.

The mural was discovered in 1866 and subsequently uncovered by the painter Stolle. At that time, the mural was also painted over and "embellished" with oil paint. Presumably this 1866 uncovering was done quite drastically on the background parts of the figurative painting, as the

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level of these background parts is everywhere 1-3 mm deeper than that of the painting itself. The crowns show this especially clearly. In the upper part of the mural, there are also distinct traces of grinding.

In a protocol of October 28, 1894, concerning the condition of the mural, parson Warnicke of Coburg writes:

"On the northern wall of the northern aisle two large medieval mural paintings, which nearly cover the entire wall, have already been uncovered in former times. They depict the coronation of the Virgin Mary in connection with a symbolic representation of Solomon's Throne, the medallions with portraits of former patrons of the hospital and their coats of arms surrounding the Maiestas Domini. These murals have been subjected to a well-meaning but not style-conforming and in many parts obviously arbitrary restoration in oil paint, or better, they have been spoiled forever, so that they cannot be considered for the question at hand, since it will not be possible to remove the overpainting to determine the original condition."

Earlier restorations

In 1938, Prof. Fey of Berlin estimated the cost for uncovering and restoring old paintings of the Holy-Ghost Hospital in Lübeck. Concerning the paintings, he wrote:

"On the northern wall, large fresco paintings have to be restored which have been completely overpainted with thick oil paint. It is extremely difficult to remove this oil paint – which in the course of time has turned as hard as stone – from the fresco paintings beneath. This has to be done with utter carefulness to avoid damaging the precious original frescoes. An experiment performed on the murals has shown that it is possible to do it in a way which brings to light the old paintings in all their earlier wonderful colour and delineation. These are rare, first-class works of art. After the oil paint has been soaked sufficiently, the paint must be removed in small pieces. Of course, on this occasion all the damage will also be exposed which the fresco had suffered prior to the overpainting. It can be seen, for example, that several parts of the background have suffered from attempts to clean the old fresco, presumably with a corrosive mordant. Fortunately, however, this attempt has been confined to the smooth background, while in the figural parts the delineation has been well preserved, so that the overall impression conveyed by the picture is still a perfect one,"

and he continued,

"After removal of the oil paint, any residual remnants of the overpainting must be removed with great patience, proceeding square inch by square inch. Then the old painting must be fixed in order to withstand exterior influences, since it is well known that frescoes that had been whitewashed or overpainted for a long time and then uncovered tend to fade if they are not immediately coated again with a fixative. After the fixing one can begin to restore the painting according to modern principles of preserving works of art. The cost of uncovering and restoring amounts to 3000.- Reichsmark for each painting."

After the restoration, in an article in the Schleswig-Holstein Yearbook, 1942-43, "Two Murals of the Early 14th Century in Lübeck and How They Were Saved," Prof. Dr Sauermann wrote the following euphoric lines:

"Removing the overpainting was an arduous and time-consuming toil which took months. Success in chemically softening the paint cover was not sufficient for guaranteeing a favourable outcome. All depended on the question if the oil paint had firmly and unremovably fused with the old fresco painting. The overpainting was dissolved and removed in small portions.

"It transpired that the old mural had been executed in excellent *fresco* technique and was quite well preserved. The western mural, however, shows some damage in the lower part of the predella painting, affecting the lower part of the garments. On the left side, the colours of the lions standing on the throne steps and the lowest angel figure have faded considerably. The lower three lions on that side have vanished entirely; otherwise, the frescoes were intact. In the course of the restoration, the dirt adhering to the painting ground was first carefully removed; then the small cracks and holes were filled with pure lime mortar and these spots covered with a translucent glaze conforming to the overall hue. In the spirit of a strict preservation, no supplementary painting was carried out, and only a casein fixative and lime water were applied for conservation purposes. [...]

"The restoration has succeeded entirely. Indeed, our boldest expectations were exceeded and the frescoes were uncovered in such purity that this monumental work of Lübeckian art now boasts nearly all of its original beauty and testifies in the very confines of Lübeck to the high standard of Lübeckian painting as no other early monument can do."

I suspect that Professor Sauermann did not have the opportunity to take a close look at the paintings from the scaffolding, because otherwise he would have quickly noticed that the oil paint has by no means been removed everywhere.

Furthermore, this is not a fresco painting, but a tempera painting. As far as can be ascertained, the thickness of the *intonaco* (plaster) varies from 1 to 5 mm. No *giornate* (dayworks) can be discerned,

Figure 1. Mural painting of "King Solomon's Throne," Lübeck. General view.

Figure 2. Detail of the mural painting.

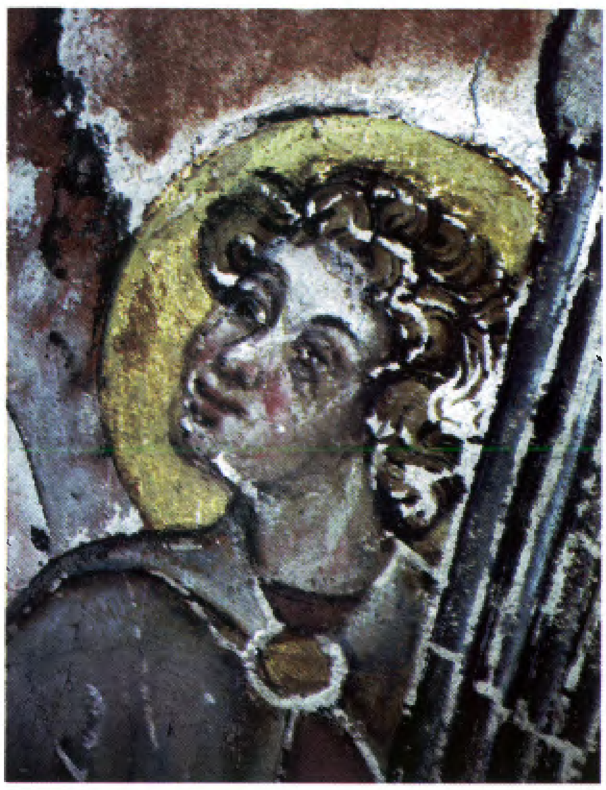


Figure 3. Detail of the mural painting.

but *pontate* (scaffolding levels) can. At this point, it cannot be decided whether it is a pure tempera technique, since the relevant analyses have not yet been completed. Proof will not be easy , however, because of later oil overpaintings and casein fixatives.

In 1980, restoration became necessary again. The loose plaster areas were backed up with a mixture of lime, marble slip and synthetic resin emulsion (Compacta); loose surfaces were soaked with a mixture of Compacta and a wetting agent (Agepon) and readhered. Stabilizations were done with silicic acid ester and Paraloid B-72 additive. As to salts, at that time Dr Kühn found sodium chloride.

In 1983, Dr Weber of the Bayplan company presented a chemical and physical assessment of the northern wall. These examinations especially found an extremely high chloride content and a high nitrate content. Measurements also showed a hygroscopic water uptake of up to 25% by weight. As a result of these examinations, a moisture barrier was established by injecting alkyl alkoxy silane (Funcosil H) into drill holes in order to prevent rising moisture from damaging the mural.

Present condition of the mural

The horizontal width of the mural is 6.60 m at the lower edge and 5.85 m at the top edge.

Parts of the mural on the northern side of the hall are in a very desolate condition – due in part to restorations in the past 125 years. The western portion of the mural especially shows considerable damage. The western wall is an exterior wall, whereas behind the northern wall there are well-heated apartments of a senior citizens' residence. The thickness of the northern wall varies markedly, due to niches and arch bays. This can also be seen very clearly in the infrared photographs (thermographs) made by Dr Berling.

In many areas, the contour drawings are chipping off, and large portions of the paint layer have already vanished. The main damage suffered by the mural, apart from the contours chipping away, is due to the paint flaking off and surface erosion. This is mainly caused by the measures taken in 1939, because attempts to remove the oil paint have considerably damaged the plaster, which is only 2 mm thick in places.

The background parts of the mural, which are now white and red, were once presumably blue. Remnants of this can still clearly be seen at the gilded crowns and nimbi as well as, in the case of the red background, in the joints of the putlog holes.

In some areas, namely where the plaster has chipped off, it is evident that beneath the painting visible now, or at least beneath parts of it, there are even older paintings.

Measures carried out

To start, archival documents were searched for usable results. It is striking that there are no reports, articles or memoranda concerning the uncovering of 1866. There are, however, numerous notes about restoration measures of 1898/99 and later.

The mural was divided into 9 segments, 3 across and 3 high, and photographs were taken. Before any work was done, the mural was also photographed in its entirety, in colour and in black and white. This overall photograph was overlaid with a grid in order to facilitate later identification of close-up photographs and sampling locations. All photographs are marked according to this grid, so that they can always be easily identified, even by someone not involved in the project.

Also, a 1204-point grid with a mesh size of 20 cm was laid over the mural in order to measure variations in the surface conductivity.

During 31 campaigns (7 in 1991; 9 in 1992; 8 in 1993; 7 in 1994), measurements were taken at always the same spots to allow comparison of data, and the results recorded on transparencies. Then the data were plotted graphically to give an easier overview. The conductivity was found to show marked differences, for example before, during and after the Christmas fair. However, in some spots the moisture content decreased during the 31 campaigns, in other spots it increased, so that in my opinion no direct correlation between the Christmas fair and the moisture content can be established yet. Some months into the campaigns, it had already become clear that the interior climate depends on the exterior climate. Close to the mural, the air velocities behave identically in vertical directions. During the heating period, the values are lower than during the rest of the time. It has often been suspected, but never proved, that the damage to the mural may be connected to increased moisture caused by the Christmas fair. The measurements showed that the entire middle part of the mural is dry, that is, that the area of increased conductivity ends at the crack which passes vertically through the mural. It is striking, however, that the highest values are found at the lower edge of the mural.

To discover whether surface condensation occurs at night, a measuring instrument was installed. The result was negative. Simultaneous to each measuring campaign, the relative humidity (RH), room temperature and wall temperature were recorded, always at the same spots. During the campaigns, it also turned out that in the middle part of the mural the conductivity inside the chipped-off contours is the same as that in the areas overpainted with oil paint.

Parallel to these measurements, the following phenomena were mapped:

- contours chipped off
- plaster repairs and putlog holes
- loss of paint layer and erosion
- injection holes of earlier restorations
- biological contaminations in field no.1156:
  a) mould and algae
  b) bacteria
- gaps and endangered plaster areas.

So far, 224 A4-transparencies and drawings have been made. In order to assess the extent of biological contamination, several samples have been taken. Additionally, in grid field no. 1156, contact samples were taken at those spots where conductivity is measured, and put on a culture medium. This field was selected because here the surface conductivity is highly variable, not only by location but also with time. It turned out that this area contains 14 species of bacteria, 13 species of mould and 2 species of algae. The distribution of the slime-secreting bacteria (B7) is remarkable in that these bacteria are found in areas of high as well as low conductivity, so that one cannot assume that the areas with higher conductivity suffer from stronger biological contamination than other areas.

In addition, before and during the Christmas fair in 1991 and during and after the Christmas fair in 1992, dishes with different culture media were exposed. In both cases, only a relatively low micro-organism count was found.

All the spots with samples taken were mapped and photographed. All in all, up to now the following samples have been taken:

- 8 samples for analysis of the binding medium, three of them from contours coming off;
- 17 samples for analysis of the salt content; and
- 15 samples for biological analysis.

So far, all the examinations have been done with basic restoration methods. Exceptions are the climate measurements by Dr Berling, the microbiological examinations by Dr Petersen, and the analysis of salts and binding media by Dr Bleuer, Prof. Jägers and Dr Steiger. The goal of this research project is to develop a concept for the restoration of this mural and others with similar or identical symptoms by proceeding methodically in the restorative and scientific analysis of the various kinds of damage and their causes. In my opinion, one should make it a principle to first try to register the damage with simple examination methods. Only then, if necessary, can high-tech methods be specifically applied. However, the mobile laboratory of the MPA Bremen provided valuable help.

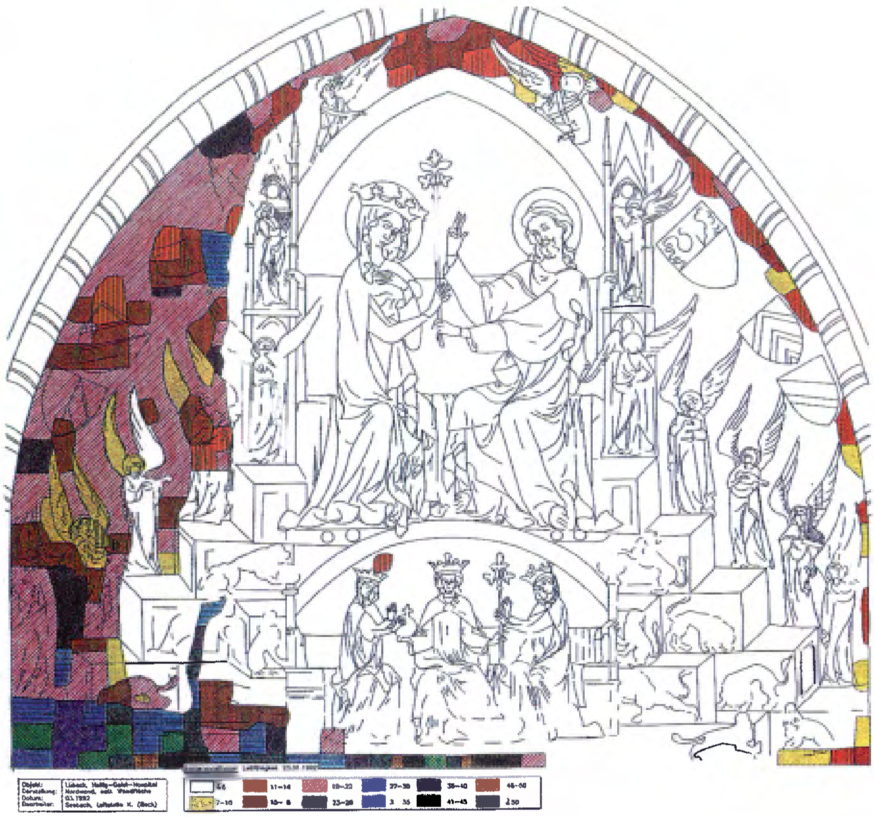
This mobile laboratory offers a unique opportunity to analyse samples immediately after they have been taken. Usually, samples are taken and sent to a qualified laboratory where the analyses are made, but transport often takes a long time and the samples can degrade. This happens especially with salts and micro-organisms.

In the top area of the mural, close to the vault cap, a somewhat thicker clod of paint was found. Upon examination, it was found that the mural had been overpainted at least 15 times before it was uncovered in 1866. The scanning electron microscope distinctly shows the different layers. Furthermore, it was found that the background above the left crown in the lower part of the picture was painted with a blue pigment containing copper, very probably azurite. In addition, gypsum was found all over the mural, partly even beneath the paint layers. The lower region of the mural has a high salt content; the wall is very moist there, however, so that the salt has not yet crystallized, which would mean further damage.

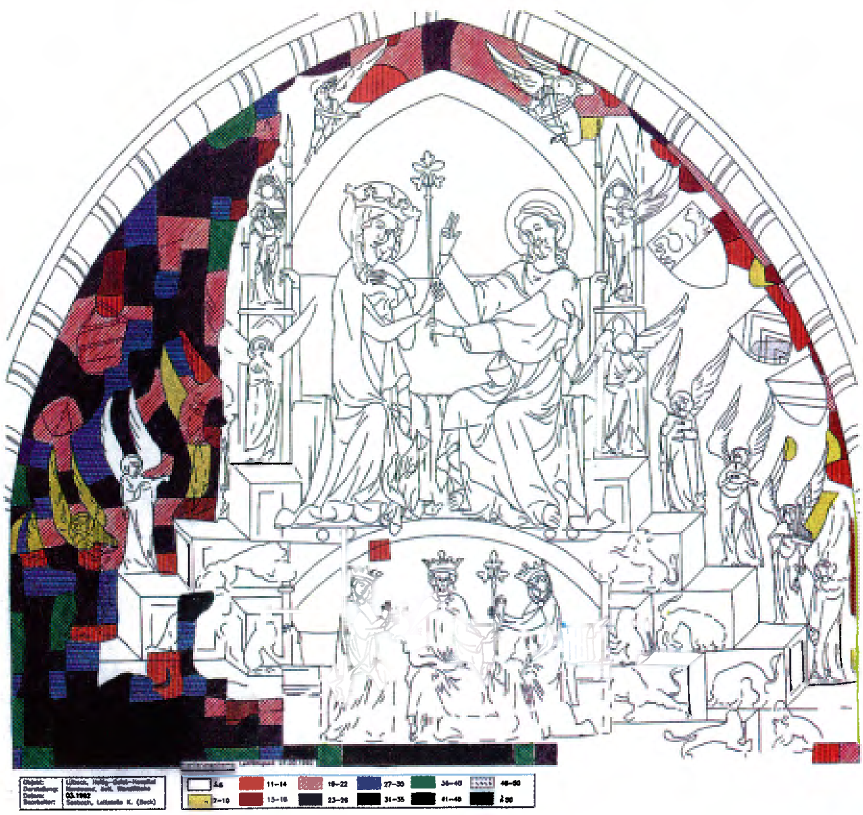
Twenty very small samples were taken in order to determine:

- which salts are in the paint and plaster layers?
- which aggregates are in the different plasters that have been applied over the years, and what is the composition of the plasters?
- what is the layer structure of the painting, and in what order have the layers been painted?
- what do the grey discolorations mean?
- what pigments have been used?

Since August, 1993, an apron has been installed at the lower edge of the mural, to intercept any particles trickling down. It is already evident that the amount of particles on the left side is twice that of the right side. All these particles are collected and analysed. From August 1993, until November 1994, a total of about 15 grams was collected. This is much less than what is falling



Temperatur Innen: **6° C**
rel. Luftfeuchte: **62%**



Temperatur Innen: **7° C**
rel. Luftfeuchte: **65%**

Figure 4. Above: Distribution of surface conductivity, 23 January 1992. Below: The same, on 21 February 1992.

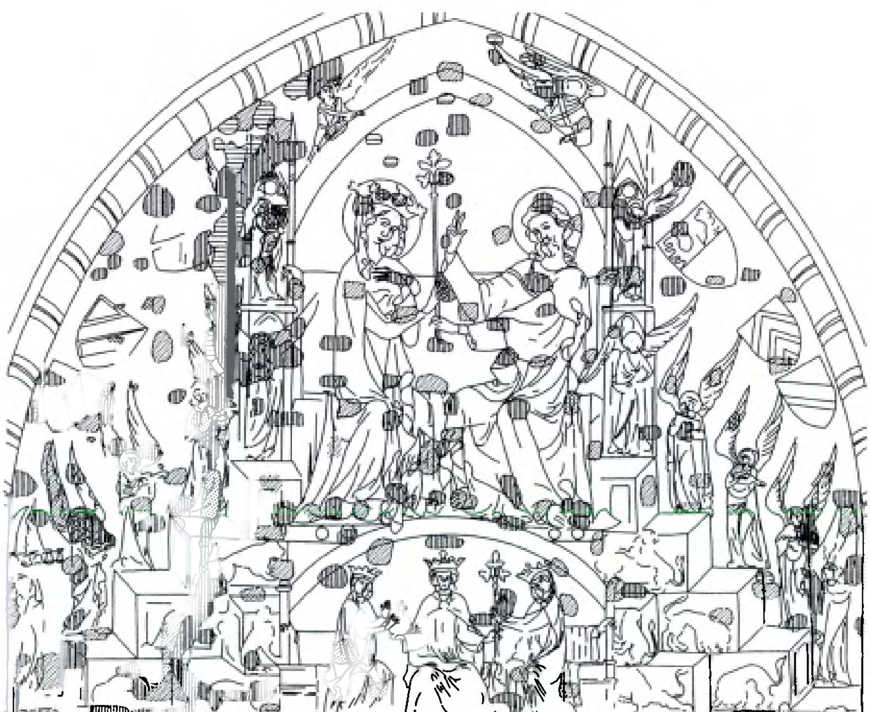


Figure 5. Above: Overview of flaking contours. Below: Distribution of gaps and lack of adhesion.

down from, for example, the Virgin Mary in the Capitol [see Häfner paper, p. 17], but extrapolation over the years indicates a considerable loss of material.

After evaluation of all the results, a concept for the restoration of the mural has been worked out, in collaboration with all those involved.

Although many questions are still not settled, the results of the examinations carried out so far can be summarized as follows:

1. Rising damp and surface condensation should be prevented by the moisture barrier installed in 1983 and the heated rooms behind the wall. In general – except during the heating period – the surface of the mural has a higher temperature than its surroundings.
2. No significant microbiological damage or threat to the mural has yet been found.
3. It can be speculated that the moisture-related damage in the left part of the mural could be connected to the exterior western wall since there is no appreciable moisture on the right side of the continuous crack, which is up to 1.5 cm wide.
4. The chipping off of the contours is presumably caused by the underpaint or the contour sketches. Further examinations are necessary, however.
5. The following pigments have been detected: vermilion, red lead, Venetian red (red hues); yellow ochre, vegetable black, malachite and other copper greens; azurite and other blue copper compounds.
6. The salts present in the surface – gypsum, chloride and nitrate – are presumably activated by the hygroscopic uptake of water, which then causes damage to the paint layer.
7. Climatic conditions contribute essentially to the destruction of the mural. RH variations higher than 40% are especially responsible.

As can be seen from the small number of results presented here, this subject is very complex. It is not sufficient to apply one of the usual stabilizing agents to consolidate the painting, as that would inevitably lead to further damage. Also, removal of some salt from the surface would only yield short-lived success, but in my opinion it is not feasible at all with this painting. This would lead to an increased migration of salt. Long-term rehabilitation requires, among other factors, development of a salt-tolerant stabilizing agent, as the currently used agents in combination with a strong salt content have always eventually caused additional damage. The salt must be accepted, since we cannot get rid of it.

The following measures are planned next:

1. monitoring in conjunction with climate measurements;
2. rehabilitation of the joints of the exterior brickwork;
3. sampling to assess the results of stabilization measures;
4. extracting drill cores from the brickwork in areas of younger plaster repairs in order to analyse the salt content in the brickwork behind the mural.

As can be seen, a complete recipe for the restoration of this mural is not yet available.

I should like to end this report with a wholehearted “Thanks.” I thank the Federal Ministry of Science and Technology (BMFT), represented by Dr-Ing. H. Schulze, because only the support of the BMFT made and still makes it possible to carry out these thorough investigations of this object which is of major importance for Lübeck.

Participating institutes:

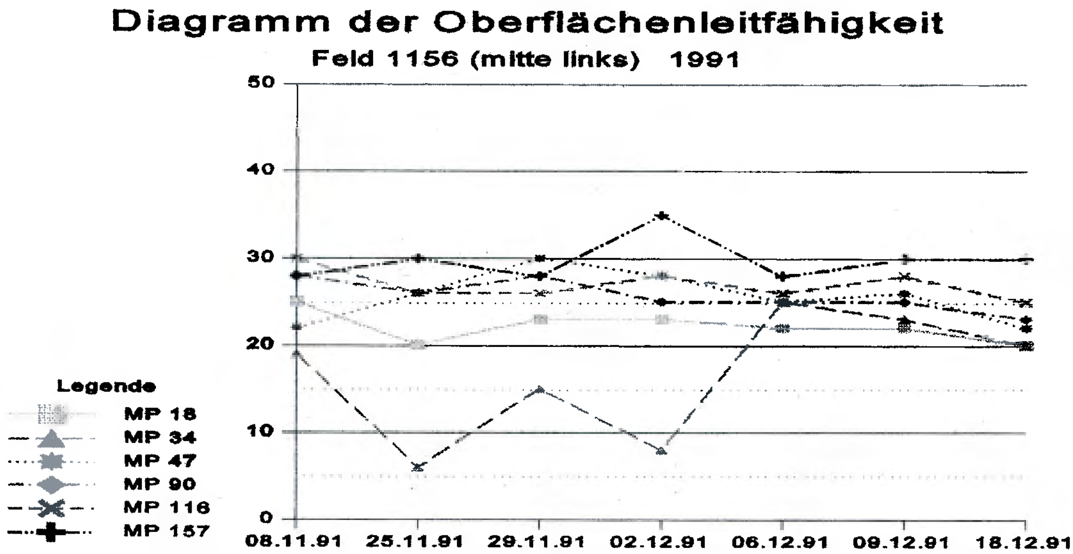
Mineralogy and salt examinations:
Dipl- Min. Eva Föllen, Jörg Schad, MPA Bremen; Dr M. Steiger, Universität Hamburg, Inst. f. angew. u. anorganische Chemie;
Dr M. Wilimzig, Universität Hamburg, Inst. für allgemeine Botanik;
Dr Chr. Bläuer-Böhm, FH Köln.

Microbiological examination:
Dr Karin Petersen, AG Geomikrobiologie der Universität Oldenburg.

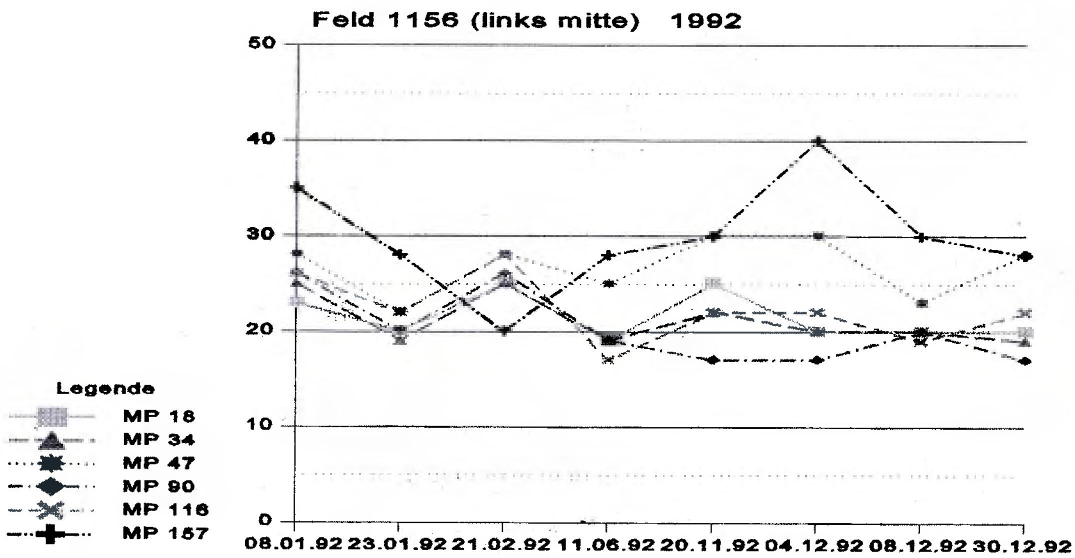
Analyses of binding agents:
Prof. Dr Elisabeth Jägers, FH Köln.

Climate and close-range climate measurements:
Dr Ing. H. Berling, Institut f. Technischen Ausbau der TU Braunschweig.

Restoration examinations:
J. Seebach, Emkendorf; Peter Taubert, Dresden; Sven Taubert, Dresden; Prof. Oskar Emmenegger, CH- Zizers.

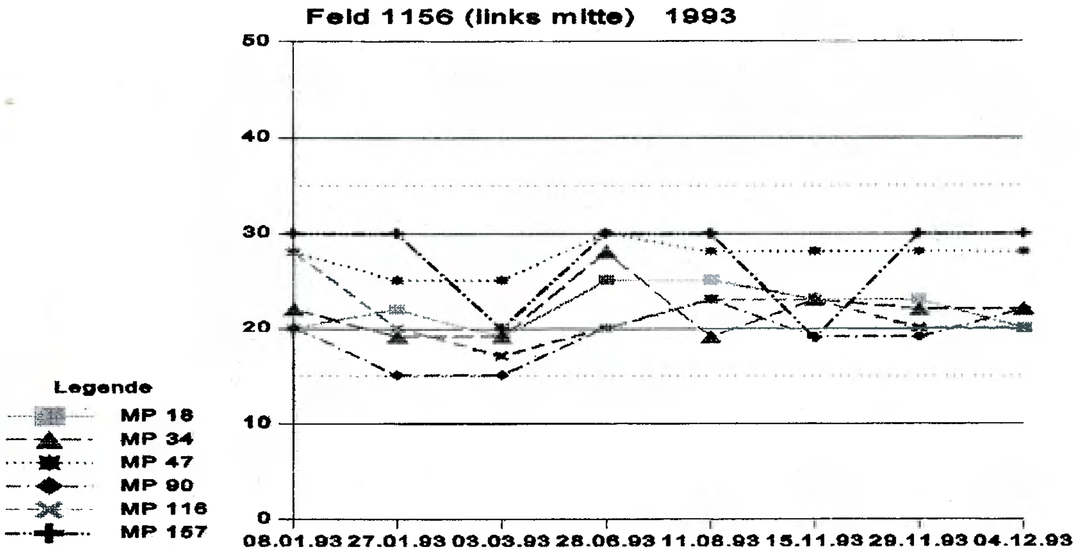


Raumtemperatur	11°	17°	20°	19°	18°	19°	8°
rel. Luftfeuchte	70%	87%	54%	61%	62%	59%	58%

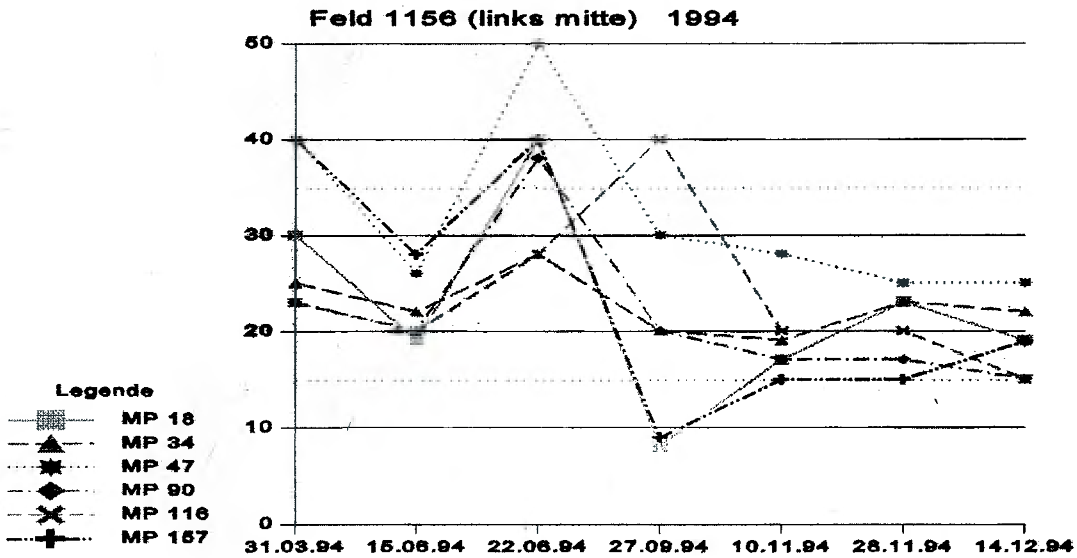


Raumtemperatur	8°	6°	7°	22°	16°	20°	17°	4°
rel. Luftfeuchte	64%	62%	65%	49%	57%	53%	54%	63%

Figure 6. Field 1156. Graphs of surface conductivity in 1991 (above) and 1992 (below).

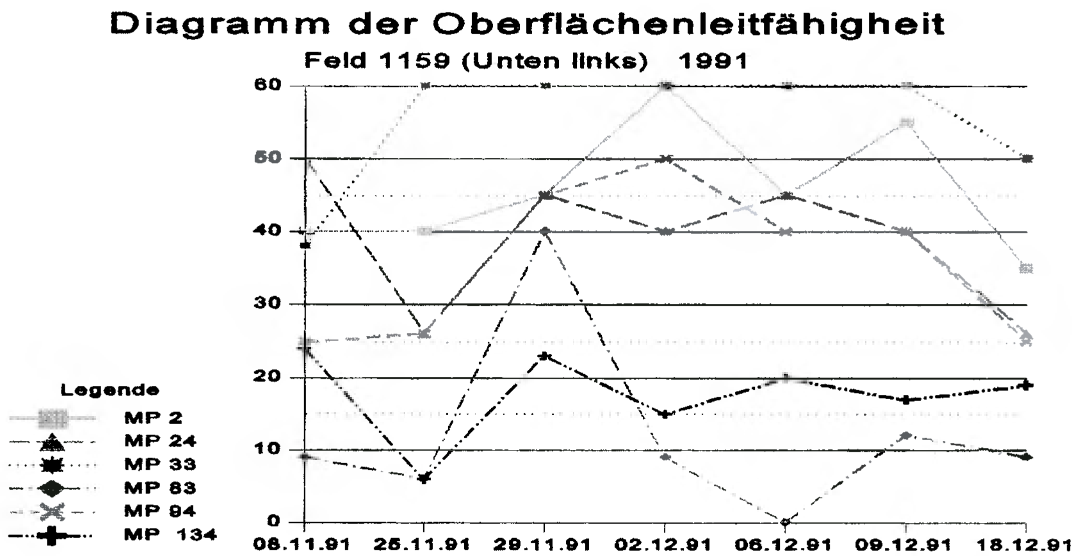


Raumtemperatur	4°	6°	3°	18°	19°	17°	20°	21°
rel. Luftfeuchte	66%	58%	54%	55%	52%	58%	55%	55%

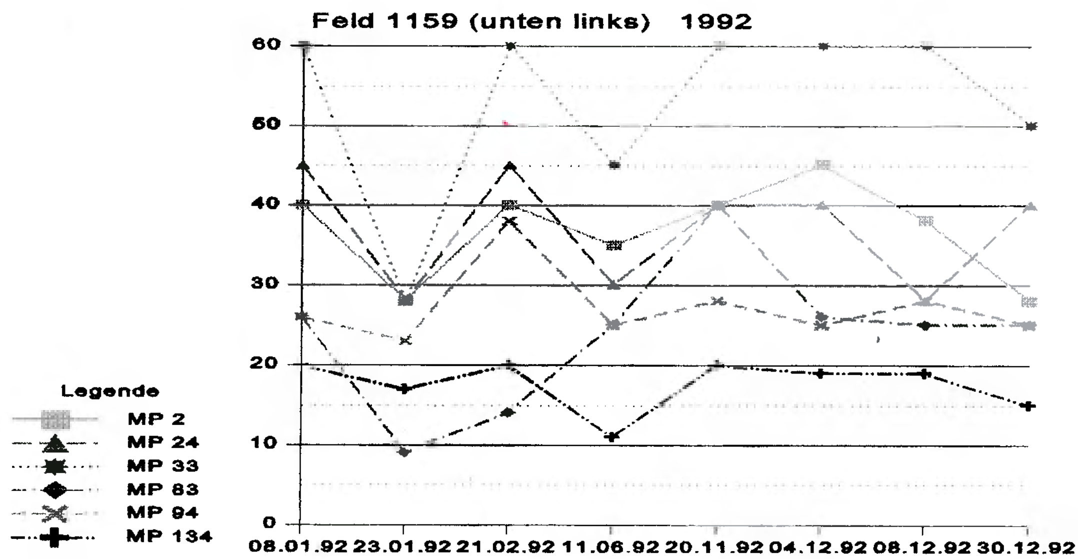


Raumtemperatur	11°	18°	18°	16°	13°	19°	12°
rel. Luftfeuchte	68%	46%	70°	61%	54%	51%	48%

Figure 7. Field 1156. Graphs of surface conductivity in 1993 (above) and 1994 (below).

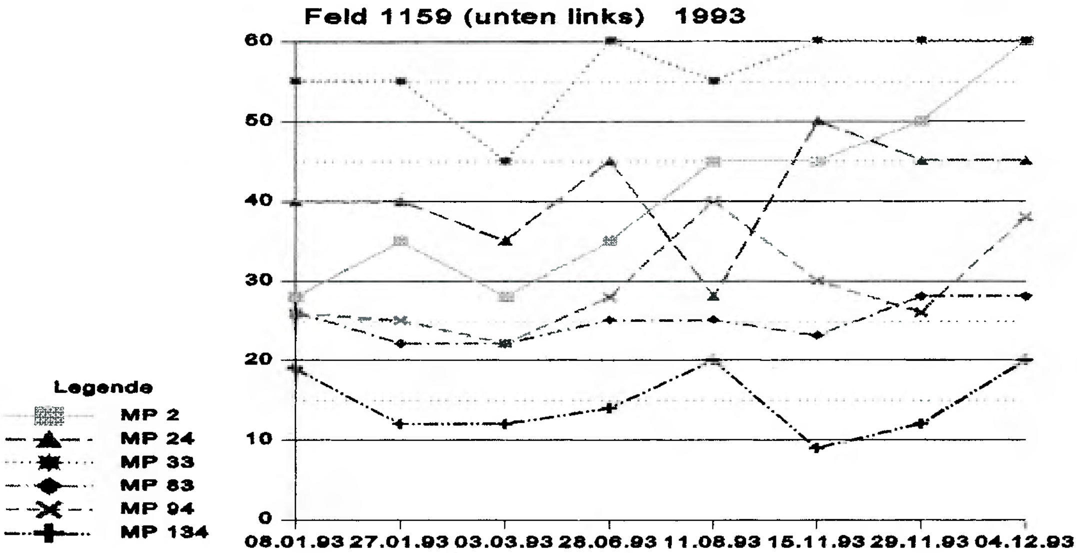


Raumtemperatur	11°	17°	20°	19°	18°	19°	8°
rel. Luftfeuchte	70%	87%	54%	61%	62%	59%	58%

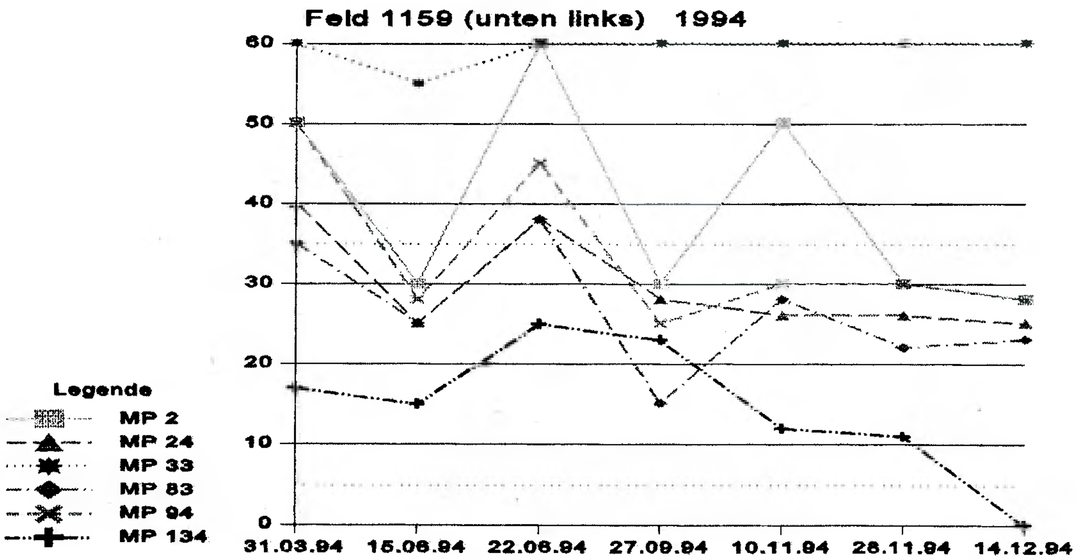


Raumtemperatur	8°	6°	7°	22°	16°	20°	17°	4°
rel. Luftfeuchte	64%	62%	65%	49%	57%	53%	54%	63%

Figure 8. Field 1159. Graphs of surface conductivity in 1991 (above) and 1992 (below).



Raumtemperatur	4°	6°	3°	18°	19°	17°	20°	21°
rel. Luftfeuchte	66%	58%	54%	55%	52%	58%	55%	55%



Raumtemperatur	11°	18°	18°	16°	13°	19°	12°
rel. Luftfeuchte	68%	46%	70%	61%	54%	51%	48%

Figure 9. Field 1159. Graphs of surface conductivity in 1993 (above) and 1994 (below).

LIME-BASED MATERIALS USED IN THE CONSERVATION OF WALL PAINTINGS IN DENMARK

Kirsten TRAMPEDACH
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ABSTRACT

Approximately 1800 medieval churches are preserved in Denmark, and medieval wall paintings are visible in a third of them. The majority date from the 11th to the 18th century. General maintenance is decisive preservation, and this is the responsibility of local elected church councils.

Work with wall paintings has to be approved by the National Museum. Conservation/restoration: cleaning is carried out with *gomma pane* or dry sponges. Water can be a chosen procedure. Impregnation: since the end of the 1940s, limewater has been the preferred material. Fixing paint layer: slaked lime and calcium carbonate powder diluted with limewater (1:1:2). For consolidation of plaster: lime caseinate and slaked lime mixed with calcium carbonate powder + limewater (1:1:2). Loose mortar can be stabilized by repairs. The overall aim is to limit introduction of consolidation materials.

Repairs are carried out with slaked pit lime which is at least 3 years old, and washed and dried quartz sand. Aggregates of different sizes are used. Integration: Only water colour or dry pigments mixed with limewater are used. Uncovering is only executed when it is necessary for preservation of the paintings. Uncovering is done mechanically by means of special hammer, scalpels and ultrasonic equipment. Exposure of wall paintings is considered a last resort. An important part of the conservator's work is prevention. The "Limewash Service" of the Wall Painting Section of the Conservation Department is in charge of the National Museum's preventive conservation activities.

Keywords: wall paintings, maintenance, cleaning, impregnation, fixing, consolidation, integration, uncovering, lime, mortar, prevention.

Approximately 1800 medieval churches are preserved in Denmark, and medieval wall paintings are visible in about a third of them. The majority date from the 11th to the 18th century and most of them were painted in the period up to the Reformation in 1536. The reason we have quite a number of wall paintings preserved in our churches is that the Reformation was introduced without any iconoclasm and probably most coverings of wall paintings took place during the Pietism movement in the 17th and 18th centuries.

In the last century there occurred an interest for wall paintings which resulted in the uncovering of a large number of decorations. The works were often executed by craftspeople supervised by professors from the antiquarian authorities. Not much attention was paid to conservation, and the restoration was aimed at overpainting and complementation. The materials used were very often based on lime and this tradition has continued in today's conservation work.

The condition of the wall paintings depends on the fact that they are an integral part of the building. General maintenance is therefore decisive for the preservation of the paintings, and in Denmark this is the responsibility of the locally elected church council.

Since the middle of the last century, the churches have been instructed to make a yearly

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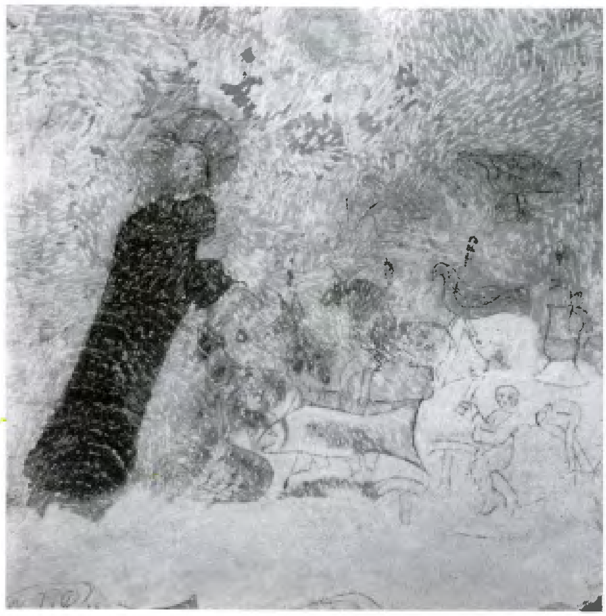

Figure 1. Aagerup church. Nave, eastern vault. 16th century. During cleaning (Wishab). Notice the limewash left on top as well as the hammer marks. Details reflecting the restoration at the beginning of the 20th century. Photo: K. Trampedach

Figure 2. Aagerup church. Nave, eastern vault. After restoration. Photo: K. Trampedach

inspection and to report defects and damage. Thereafter, any ordinary maintenance of the building is expected to be carried out as soon as possible, ideally before the next inspection. Major works are always supervised by specialized architects.

All work dealing with wall paintings has to be approved by the National Museum, which has the overall antiquarian responsibility. Most restorations are carried out by conservators of the Department of Conservation of the National Museum.

CONSERVATION/RESTORATION

Cleaning

Cleaning is carried out by using *gomma pane* or dry sponges (Wishab - Hart). *Gomma pane* made and used in the right way is the most careful solution.

Gomma pane [bread eraser]: 700 g boiling water, 50 g copper sulphate, 40 ml soda, 780 ml flour. Wrap the *gomma pane* in gauze, tin foil, wet linen and tin foil. Bake in the oven at 170°C for 1½ hours.

If the colours are resistant, water can be the chosen procedure; if the colours are less resistant, clean through Japanese tissue.

During re-restorations, decisions are made whether or not to remove earlier restorations (overpaints and reconstructions). As most restoration work, as mentioned above, has been carried out on lime-based materials it has no important influence on the preservation of the paintings. The final decision is based on technical, antiquarian, aesthetic, historical and/or economic aspects, and often the choice is to preserve the former restoration.

Impregnation

Impregnation is only carried out when necessary for the preservation of the paintings. In general that means when the paint layer is powdery. Since the end of the 1940s, limewater has been the preferred material, applied by spraying. Before application, the wall is humidified with water for a better penetration, and the spraying of limewater must be carried on until the paintings are saturated. It is important not to overdo the process, as you risk to create an insoluble film of calcium carbonate on the surface.

The effect of this treatment has so far not been proved scientifically but research made by conservator Isabelle Brajer in cooperation with chemist Nicoline Kalsbiik during 1995 (School of Conservation, Copenhagen) has given interesting results, which will be published in 1996.

Fixing of paint layer

If possible, a mixture of slaked lime and calcium carbonate powder diluted with limewater (1:1:2) is used.

If this method is insufficient, Primal AC33 or a polyvinylalcohol are the alternatives.

Figure 3. Aagerup church. Nave, northern wall. 14th century. During restoration. Lime mortar repairs. Photo: Roberto Fortuna

Figure 4. Aagerup church. Nave, northern wall. 14th century. During restoration. Limewashing of repairs. Photo: Roberto Fortuna

Consolidation of plaster

The materials for consolidation are also based on lime. Lime caseinate and slaked lime mixed with calcium carbonate powder + limewater (1:1:2) are the preferred materials. The lime caseinate consists basically of 1 kg slaked lime and 100 g caseinate. The strength can be varied by adding, e.g., a lime and sand mixture (based on 1 part sand – up to 0.4 mm – to 4 parts lime putty).

Being aware that what is introduced into a wall or vault cannot be removed means that one works with restraint and keeps the consolidation to a minimum. Often a loose piece of mortar can be stabilized by repairs, for instance, of cracks or lacuna which bring the loose rendering back in tension. If you find hollow spaces behind the rendering normally it is not necessary to fill them out – only if the plaster moves under pressure. In such cases the injections are made to establish fixing points. The overall aim is to limit the introduction of consolidation materials.

Mortar repairs

Repairs of lacunae are carried out with lime mortars produced by using slaked pit lime which is at least 3 years old, and washed and dried quartz sand. The aggregates are of different sizes depending on the use. With the use of mortars it is not important to

Figure 5. Aagerup church. Nave, northern wall. 14th century. After restoration. Photo: Roberto Fortuna

Figure 6. Aagerup church. Interior after restoration. Photo: Roberto Fortuna

reproduce a material identical to the original one. The main purpose is to create a material that is more porous than the surroundings and should also be easy to use and remove. Based on analysis of selected medieval mortars, 3 compositions are used. Depending on the purpose, the aggregates go up to 1.5 mm, 2.2 mm and 5.0 mm. The first two sizes serve for surface repairs, the latter for deep fillings.

Table of aggregates

Depth to be filled	%	mm
Max. 1.5 mm:	10	0.0 - 0.3
	15	0.2 - 0.5
	35	0.4 -0.8
	30	0.8 - 1.2
	10	1.0 - 1.5
Max. 2.2 mm:	10	0.2 - 0.5
	15	0.4 - 0.8
	20	0.8 - 1.2
	25	1.0 - 1.5
	20	1.4 - 1.8
	10	1.7 -2.2
Max. 5.0 mm:	5	0.2 - 0.5
	10	0.4 - 0.8
	15	0.8 - 1.2
	25	1.0 - 1.5
	20	1.4 -1.8
	15	1.7 - 2.2
	5	2.0 - 3.0
	5	3.0 - 5.0

The table is based on analysis by conservator Mogens Larsen.

The aggregates are mixed with slaked lime : 1 lime : 2 ½ or 3 aggregates.

For small cracks where the material has no consolidating purpose and is only used as a filler: slaked lime is mixed 1:1 with quartz sand 0.0-0.3 mm.

After a period of setting, the mortar surface is treated by cutting with a trowel or spatula. In this way the surface is open for drying and carbonation and at the same time the structure should be such that eventual evaporation happens more easily through the repaired part than the surrounding original mortar/paint layers. This is of great importance when working on walls where a certain degree of dampness nearly always exists. If the surface of a repair is too tight, the salts will crystallize next to the repair and deteriorate original mortar or paint.

How the final treatment of the repairs is carried out depends on aesthetic decisions. For Gothic paintings, which are executed on a layer of limewash, a similar lime will be applied. For Romanesque paintings we often choose a mortar as a neutral material.

Integration

The integration of wall paintings is a matter of materials and methods. As to the materials, only watercolour or dry pigments mixed with limewater are used for retouching today. Lately, pastel crayons have also been tested for certain purposes. The principle of integration is ambiguous. Each case has to be treated individually, but problems can be divided into two main groups: re-restoration and conservation of recent discoveries. One of each type is illustrated: Aagerup church – a re-restoration of 16th-century paintings, and Gundsomagle Church – a recent discovery of 14th- and 12th-century paintings.

Uncovering of wall paintings

Wall paintings are uncovered only when necessary for their preservation. That often means when a synthetic binder has been added to the covering limewash; this prevents the walls/vaults from "breathing," and the painting will eventually deteriorate. Another reason for uncovering can be that the limewash layers on top are very thick and have started to loosen because of surface tension. In these cases we can often treat the surface once more by a special limewash technique, but it may be that uncovering is the final result.

The uncovering is done mechanically by means of a special hammer. The two cutting edges are at right angles to each other. Knives, scalpels and ultrasonic equipment are also used. The tool chosen depends of course on the state of painting and layers of limewash. Before top layers of limewash are removed, a stratigraphy is done to place the layers chronologically with respect to the paintings and eventually the archaeology of the building. The stratigraphy is supplemented by cross-sections.

There are still many medieval wall paintings hidden behind the limewash layers in our churches. However, as an agreement between curators and conservators, the National Museum decides the paintings should remain there as long as possible – provided, of course, that the structure of the church is generally sound and in good repair with the right materials of maintenance. The exposure of wall paintings is considered as a last resort after all other alternatives have been considered. Consequently, an important part of the conservator's work has become thinking in terms of prevention in order to keep the paintings under limewash. For this reason, much attention is attached to the counseling of parish councils, architects and craftsmen concerning the treatment of the surfaces.

A "Limewash Service," in charge of the National Museum's preventive activities, has been established under the Wall Painting Section of the Conservation Department. The parish councils of the individual churches are under no obligation to avail themselves of the Limewash Service, but in order to allow us to share our viewpoints and proposals we offer a free first visit to the church. If there is any suspicion that limewash on the existing layers may present a problem, it will then be proposed that a test be made according to the instructions given by the conservator. The tests will serve as the basis for any further decisions for definitive treatment. At the same time this procedure also enables the craftsmen to price the job. And most important: the conservator gets the chance to register and save wall paintings!

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Figure 7. Gundsomagle church. Nave, western wall. 14th century. During restoration. Photo: Roberto Fortuna

Figure 8. Gundsomagle church. Nave, western wall. 14th century. After restoration. Photo: Roberto Fortuna

Figure 9. Aagerup church. Interior during restoration. Photo: Roberto Fortuna

Figure 10. Repairing with lime mortar in Aagerup church. Photo: K. Trampedach

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