Nidaros Cathedral, Trondheim, Norway

Conservation of Mural Paintings and Paint on Stonework in the Choir’s North Aisle Vault

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This report documents investigations and conservation measures related to mural paintings on cells in the easternmost medieval vault in the north aisle of the choir of Nidaros cathedral. It also describes investigations of paint on soapstone decorations nearby. The fieldwork was undertaken in March 2002, simultaneously with the interior cleaning of the whole choir.

Possibly dating to a large renovation undertaken in the 1630s, the paintings are the most well-preserved in the cathedral, but unfortunately their state is today quite fragmented, mainly due to various early damages and renovation measures. After their uncovering during the cathedral restoration in the late 19th century, the paintings have been strongly influenced by water leaks through salt-laden stonework, which have added to their deterioration.

The mural paintings, showing tendrils and flowers, and the polychrome stonework are quite simply executed. It has not been possible to reveal the exact painting techniques, but the pigments used are mainly red and yellow ochre, and in addition hematite red and green verditer on the mural paintings.

Conservation measures included manual/mechanical cleaning without chemicals (dust and dirt, salt), fixing of exfoliating paint and limewash with acrylic resins, and repair of open cracks with lime mortars.

As the first work of its kind at Nidaros cathedral, it is recommended to follow the study up, especially with regard to paint fragment in the octagon, which is to be cleaned in the near future.

Cover photo: The salt epsomite (magnesium sulphate) along the borders of fragmented tendrils painted with hematite red (easternmost vault in the choir’s north aisle)
Preface

The polychrome dimension of Nidaros cathedral and other historic stone monuments in Norway is a largely overlooked field of study. Some studies of mural paintings do exist, but investigations of paint applied on stonework has to our knowledge only been undertaken once before – by Margrethe Moe during her studies of the north renaissance portal of the Church of the Holy Cross in Bergen in the late 1990s.

This report can thus be looked upon not only as a documentation of investigations and conservation of painted surfaces in the north aisle of the choir of Nidaros cathedral, but hopefully also as a contribution to the painted dimension of Norwegian stone monuments.

Thanks to all people involved in the work, especially the contributors to the report (Ann Meeks and Andreas Küng) and to Øystein Ekroll for providing historical information relating to the mural paintings in the choir. Thanks also to the restoration Workshop of Nidaros Cathedral for all practical help during the work.

Where not otherwise mentioned, photos in this report were taken by the undersigned

Zürich in December 2002
Per Storemyr
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1 Introduction

The mural paintings on the vault in the easternmost bay of the choir’s north aisle are some of the very few remaining painted surfaces in Nidaros Cathedral. The paintings, showing tendrils and flowers, possibly from the early 17th century, belong to the only remaining medieval vault in the choir.

In the course of the current choir restoration, which began with interior cleaning in the winter and spring of 2002, it was decided to investigate and conserve the murals. The work was carried out over two weeks in the beginning of March 2002 as a co-operation between the Restoration Workshop of Nidaros Cathedral, Archaeological Museum in Stavanger (AMS) and Expert-Center für Denkmalpflege in Zürich (ECD), with Ann Meeks (AMS) as responsible conservator and Per Støremyr (ECD) as conservation scientist. In addition, Andreas Küng (ECD) helped analysing paint samples taken during the fieldwork.

This report describes the vault, its paintings, damages and conservation. Moreover, a brief review of the painted dimension of Nidaros Cathedral has been included.
2 The painted cathedral

As the restored and reconstructed Nidaros Cathedral presently appears, it is almost without visible signs of painted surfaces. However, in the Middle Ages we have to assume that large parts of the cathedral were painted, especially coursed rubble walls in the transept (plastered and with wall paintings), but also various decorative elements in the entire cathedral (polychrome). After the Reformation we have indications that parts were painted, repainted and overpainted several times; we especially know that interior and exterior parts were whitewashed and that grey “stone colour” was used on a lot of interior surfaces. Such colour has also been observed on exterior stonework (figs. 6 and 7).

During the restoration, especially between 1869 and c. 1900, fragments of paint and whitewash were efficiently removed from most masonry and decorative surfaces. However, documentation and conservation efforts with regard to paint were also undertaken at some occasions. There exist for

Figure 4: Reconstructions of painted vaults in the easternmost part of the north aisle of the choir (cf. fig. 1). The originals and various copies can be found in the archive of the restoration Workshop of Nidaros Cathedral (cat. no. 577, 582-585, 586-87).

Figure 5: Polychrome arch of the octagon’s north chapel. Reconstruction on the basis of observed fragments by Christie. The original belongs to “Fortidsminneforeningen”. (Cat. no. FF 101).

1 See Storemyr (1997:116). In Lysaker (1973) there is much information about post-reformation painting.
instance three drawings of painted surfaces; one shows the polychrome (red and yellow) arch to the northern octagon chapel (fig. 5), the other the mural paintings on the medieval, easternmost vault in the north aisle of the choir (fig. 4). Paint was also used during the restoration; examples include the high altar (1882) and Christie’s decorations of the choir vaulting (1890), which still exist, but were overpainted around 1930.

In November 1999 brief inspections with regard to painted surfaces were undertaken in the octagon and choir of the cathedral. In the octagon paint fragments were especially found in the northern chapel (fig. 9-11), whereas in the choir several fragments are located in the blind arches on the north wall in the easternmost bay in the north aisle (fig. 8). Moreover, all earlier documented fragments were rediscovered.

Interestingly, it seems that similar motifs can be found in the choir and the octagon. There are at least fragments of red and green tendrils and leaves at both places (cf. fig. 1, 4, 8-10). This indicates that the paintings may have been executed during the refurbishing of the cathedral by lord (“lensherre”) Oluf Parsberg in the 1630s (cf. Lysaker 1973:74ff). The best indication is that the paintings in the choir’s north aisle must have been covered by the burial chamber made for major general Reinhold von Hoven, which was erected in 1680 (ibid. 94f) and removed during the restoration (1870s); thus the paintings must be older than from 1680. Whether the polychrome arch to the north octagon chapel was also painted at this occasion is unknown.

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2 Undertaken by Øystein Ekroll, Andreas Franz and P. Storemyr
3 Architect Christie, in his report from the second half of 1873, also notes that similar paintings could be found on the surface of the secondary wall inserted along the choir’s north arcade after the 1532 fire.
Figure 8: Fragments of tendrils on the blind arcade in the north aisle of the choir, just below the painted vault.

Figure 9: Fragments of tendrils by the north window of the north octagon chapel.

Figure 10: Fragments of tendrils and a green flower or leaves by the north window of the north octagon chapel.
During the investigation and conservation work in March 2002, we also found much red and yellow fragments of paint on the boss in the easternmost north choir aisle vault (fig. 13), as well as on ribs and arches in the area. This paint may perhaps belong to the same period as the remaining fragments on the arch to the north chapel of the octagon.
Figure 13: Fragments of paint on the boss and ribs of the vault in the easternmost part of the north aisle of the choir.

The remains of paint in the cathedral have never been properly investigated and art historically interpreted. There exist for instance no database on location of fragments found. As the current restoration will continue with, for instance, interior cleaning of the octagon, it would seem an important task to first properly locate remaining paint fragments. We have probably only located a fraction of all that can be found in this part of the church. The same holds for other medieval parts of the cathedral, both inside and outside (fig. 14).

It should be noted that the best-known mural paintings in Trondheim, the early 17th century paintings in the Regalia room in the Archbishop’s Palace, are of a different type than those described above in the cathedral. Although tendrils represent the main motif also in the Regalia room, style and – as we shall see below – painting technique are of another kind.4

Figure 14 (right): Romanesque corbel head on the exterior of the south transept. The corbel is painted, but a fire has made the paint unrecognisably brown.

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4 For a description of the mural paintings in the Regalia room, see Odén (1999) and Franz & Storemyr (2000). See also the website of the conservation project in the Regalia room: www.ecd.ethz.ch/regalia.
3 The murals on the vault’s cells

The quadripartite vault in the easternmost part of the choir’s north aisle is the only medieval one left in the choir. It is 50-60 cm thick, built by flat (greenstone?) slabs put edgewise (fig. 18) and has dogtooth ornamented ribs and a boss made from soapstone (fig. 13). Originally, in the 13th century the vault was built using lime mortar/plaster and it seems that lime (or weak lime cement) mortars were also used for repairs to some of the cells during the restoration in the 1880s. At that time the upper side of the vault was also covered by a layer of cement (see chapter 5). Stonemasons’ marks indicate that the vault was built by the same masons that were also active in the rest of the choir. Øystein Ekroll (pers. comm.) suggests that the fact that the vault is still in place indicates that the rest of the choir was dismantled in a controlled way rather than having collapsed during the fire in 1532.

HISTORY AND PIGMENTS

Only three cells of the vault have preserved mural paintings (figs. 15-17). These are today fragmented and very weathered, but all of a similar nature. In order to get a glimpse of how they may have once looked like, the reconstructions in fig. 4 are of great help. The paintings are purely decorative showing thin, winding red-green tendrils and red and green flowers or leaves. They today have yellow-orange frames, but these must have been applied during the restoration in the 1880s. Parts of the frames are now under the grey paint/wash from c. 1930 (appendix 4). According to the biannual reports of architect Christie, the murals were uncovered below many layers of limewash and plaster in 1880 and preserved, possibly without treatment, as islands within the otherwise repaired vaulting in 1885. Since then it is unlikely that they have undergone treatment of any kind.

Although the ground on which the paintings have been executed is extremely fragmented, uneven and difficult to interpret, it would seem that the technology and stratigraphy of the paintings themselves are fairly straightforward: On the uneven and usually very fat limewash(es) covering earlier, coarse lime plaster, the paintings have been executed al secco by the use of red ochre (iron hydroxide), green verditer (synthetic malachite/basic copper carbonate) and hematite red (see analyses in appendix 3).

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5 Reports from the first half of 1880 and the second half of 1885.
Figure 15:
Plan of the vault with designation of the different cells. Orange cells have preserved paintings.

Figure 16: Painting in cell V_N. The red and green flowers/leaves are easily visible.

Figure 17: Painting in cell N_V. Repainted tendrils with strong red colour can be seen – they are probably from 1885.

Figure 18: Painting in cell O_S. Only very small fragments are left.

Figure 19: Cell S_O under restoration in the spring of 2002. Note the flat slabs put edgewise for the vault construction. Photo: R. Langås.
Red ochre is mainly found on the flowers/leaves (fig. 20, 21), but is also present – at some places – below the strongly red colour (hematite red) on the stalks/tendrils (fig. 24). Moreover, it can be found as hardly visible patches throughout the cells. It is perhaps possible that these patches represent earlier paint phases? The hematite red on the stalks is very loosely bound and appears at some places to have been applied later than the red ochre layers.
Location of detail photos and samples, see appendix 3 and 4

Figure 26: Green flower or leaves in cell V_N. The green colour has significantly faded. Dark lines are pencil strokes, possibly made as help for the reconstructions shown in fig. 4. Pencil strokes are generally very common on the paintings. 
Photo no. V_N_Det_04.

Figure 27: Fragment of green flower/leaves in cell N_V. Above the green layer is a thick, secondary gypsum crust, which contributes to making the layer dark/grey. Many parts of the green are however much darker than shown – and without gypsum crusts. 
Photo no. N_V_Det_07.

Figure 28: Dark paint layer below a layer of limewash. The dark layer was originally green, which can be seen at the far left (arrow). The upper grey layer is a gypsum crust. Sample no. 070302_11. 
Width of field c. 3.5 mm.

Figure 29: Polished section of sample 070302_11. Microphoto. The spherical pigments are green verditer. They have their original colour inside, but have been altered along the periphery to become brown. Width of field c. 90 µm

It is unlikely, though, that the hematite red was applied as late as during the restoration in the 1880s. At that time (or somewhat earlier) the paintings were subjected to pencil strokes in order to emphasise the outline of the paintings, especially the green parts (see fig. 20), which thus must have been in a rather bleached state by then. It would seem that the pencil strokes are a measure rather incompatible with simultaneously painting parts of the murals dark red.

The green verditer found in the green paint layer on flowers/leaves and along the stalks is chemically similar to malachite, but since it is synthetically produced, it has a spherical form. Its manufacture is documented to as early as 1657, but it is probable that its use goes even back to the late middle ages. Green verditer was a cheap pigment, but as it had a tendency to bleach or become pale (due to e.g. chemical reactions with oil binders), it is rarely found on paintings after the 18th century. It was however used for interior
house paints until much later. The bleaching of green verditer may also be connected with its reported moderately permanency towards alkaline solutions. The darkening of the pigment, also observed on our paintings, has been said to originate from its incompatibility with sulphides. In our case it might be that the large amounts of sulphates from weathering processes play a role in the darkening, as discussed in chapter 5.

**ANALYSES OF PAINT BINDERS**

The layers of red ochre and green verditer on the mural paintings might contain (wet)slaked lime as part of the binder, whereas it is unlikely that this is the case with regard to the hematite red layers, as indicated by microscopy (appendix 3). Thus, additional paint binders would have been in use.

Two samples were selected for analyses of paint binders other than lime: 070302_08 and 070301_12 (for location, see appendix 4). The samples were tested with microchemical methods for the following binders:

- Binders with protein, for instance various forms of animal glue, egg yolk (for tempera) and egg white, as well as casein (pyrrole derivative test)
- Binders with drying oils, for instance linseed oil (glycerol test, and test with nitric acid)
- Binders with carbohydrates, for instance various forms of resins, as well as Arabic gum (test for solubility in water)

In addition, polished sections of the samples were stained with “Sudanschwarz” (for detecting drying oils) and “Amidoschwarz AB3” (for detecting proteins).

Unfortunately, none of the tests gave positive indications for any of the binders. The most likely reason for this is that the amount of tested material was too small; the amount of binders is below the detection limit. Thus, in order to be able to detect binders in paint fragments at Nidaros cathedral in the future, one should consider taking relatively large samples. Moreover, analytical techniques such as FTIR (Fourier Transformed Infrared Spectroscopy) and GC-MS (Gas Chromatography – Mass Spectrometry) should be put in use.

**DISCUSSION ABOUT THE OCCURRENCE OF GYPSUM**

In almost all paint samples relatively large amount of gypsum can be found (appendix 3). It is likely that much – if not all – of this gypsum derives from weathering processes, as discussed in chapter 5. However, it is interesting to note that large amounts of gypsum also have been found on late medieval Swedish mural paintings – gypsum that probably cannot be derived from weathering processes. In these cases, it has been speculated whether the gypsum could have been deliberately mixed with limewash below in order to

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6 Gettens & West Fitzhugh 1993. See also: http://home.debител.net/user/buder.a/html/pigmente2.htm
7 Analyses were undertaken according to methods given in Schramm & Hering 1988.
8 Nord & Tronner 1996:72f
make the paint better adhere to the ground. Whether this could also be the case with “our” mural paintings cannot be verified at present, but should be born in mind for future research.

**SUMMARY OF PAINT ANALYSES AND PAINT TECHNOLOGY**

The mural paintings on the cells of the vault in the north aisle of the choir are very simple ones, executed *al secco*, possibly in the 1630s, on partly old and fragmented limewash and with cheap pigments such as red and yellow ochre, green verditer and hematite red. It has not yet been possible to determine binders other than possibly lime in the paint layers. However, they contain much gypsum, probably mostly derived from weathering processes.

Compared to the mural paintings in the Regalia room in the nearby Archbishop’s Palace, executed by master painter “Björn Maler” around 1616 (fig. 30), the paintings in the cathedral are rudimentary. Not only are the paintings in the Regalia room made by a master, they have also been executed using a greater range of pigments, among them expensive ones like orpiment and cinnabar.  

Thus, as the paintings on the cells of the vault in the choir seem to represent a general scheme also to be found in other parts of the cathedral, one should perhaps question the assumption that they are made only 15 years after the paintings in the Regalia room (see chapter 2). For a non-art historian, it seems a bit strange that the cathedral was equipped with such rudimentary paintings at this stage, especially since they appear to be part of the extensive renovation of lord Parsberg. For future research, it seems to be important to keep these differences between the cathedral and the Regalia room in mind.

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9 For a description of the mural paintings in the Regalia room, see Odén (1999) and Franz & Storemyr (2000). See also the website of the conservation project in the Regalia room: www.ecd.ethz.ch/regalia.
4 The painted soapstone decorations

Paint on soapstone decorations in and close to the vault in the north aisle of the choir is confined to the ribs with its dogtooth ornaments, the boss, as well as weathered arches on the north wall beside the window (see also description in appendix 5). Only red and yellow paint have been found, but green might also have been present. Due to the mainly greenish to bluish colour of soapstone, green colour fragments will be very hard to see, and it was not found during the fieldwork.

RESULTS OF THE PAINT ANALYSES

In most cases it seems that the paint has been applied directly on the stone, as it generally can be found also on weathered and damaged parts (see analyses in appendix 2). This generally indicates that the surface was not particularly well smoothed or prepared with a ground before application of the paint layer. In two cases paint on the ribs appears to have been applied on layers of earlier limewash – perhaps limewash that was also used for the painting on the vault’s cells (fig. 32, 33, 34).

Pigments found include red and yellow ochre, and it would seem that the colours have been mixed with finely ground limestone (as filler). However, it is difficult to state whether the lime really is filler or lime from limewash – in other words that the lime technique was used during the painting.

The reason why it is hard to properly describe the painting technique is the large amounts of gypsum present in almost every sample – like in the samples from the murals on the cells of the vault (chapter 3). The gypsum probably derives from weathering processes (chapter 5), and so represents transformation of original lime in the paint layers. This means that it is not possible to find out whether the original lime was ground limestone or (wet)slaked lime in a limewash mixed with pigments. Moreover, it cannot be completely ruled out that the gypsum in fact is part of the painting technique – as filler in, for instance, a glue or tempera-based technique.

Unfortunately, upon analysing sample no. 110302_02 for binders other than lime, no traces of drying oils, protein or carbohydrates were found.10 As with

10 Methods described in chapter 3.
the similar analyses of binders in the paint on the cells, it is likely that – if such binders are present – the amount of material is too small for detection. 

Location of detail photos and samples, see appendix 2

Interestingly, in a couple of samples, originally though of as only containing “dirt”, a pigment combination of yellow ochre, charcoal black and possibly ultramarine has been found (appendix 2). Perhaps this represents part of the original colour scheme on the ribs – or maybe a green colour?

Due to the limited amount of paint fragments present it has not yet been possible to reconstruct the full colour scheme on the painted soapstone decorations.

**COMPARISON WITH ANOTHER PAINTED SOAPSTONE OBJECT**

Painting on stone has, according to our knowledge, only been investigated once before in Norway, by Margrethe Moe during her investigations of the renaissance portal (1632) of Church of the Holy Cross in Bergen in the late
Moe found numerous traces of ground and paint showing that the portal was once lavishly decorated and very colourful. Due to the extremely small fragments found, Moe was not able to reconstruct the full colour scheme.

However, Moe found indications that several types of techniques for making grounds had been in use:

- White lead, probably in drying oil
- Chalk (or finely ground limestone), possibly in glue
- Ground gypsum, possibly in glue

Moreover, she found remains of the use of silver foils on which green verdigris had been applied.

All these are classic techniques for making ground and insulation layers on wood as well as on stone, showing that painting on soapstone in the 1630s did not deviate from painting on other substrata. On the portal of the Church of the Holy Cross a wide range of pigments were also found, among them barium sulphate, red and yellow ochre, red lead (minium), cinnabar and verdigris.

Interestingly, at several places, especially related to very delicate soapstone carving paint, primarily cinnabar, was found directly on soapstone (without ground). Moe’s interpretation was that in such cases it would be difficult to apply a ground, and that on extremely dense soapstone there is generally less need for grounds than on more porous stone. Moreover, cinnabar is a pigment with very good covering properties.

If the paint on the soapstone decorations on the vault in the choir of Nidaros cathedral is contemporary with the murals of the cells here, they may have been made in the 1630s, thus they may be contemporary with the painted portal at the Church of the Holy Cross. Comparing the two painted objects, it becomes clear that the painting in the cathedral is quite rudimentary, for instance because paint has been applied directly on very weathered stone (without attempting at smoothing the surface) and because a limited range of inexpensive pigments was used.

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11 Moe 1998
12 Cf. Manfred Koller, undated
5 Damages and weathering processes

A lthough situated inside the cathedral, the painted vault has been heavily influenced by the Trondheim weather. The key is water leaks in this sensitive part of the cathedral.

WEATHERING SITUATION AND INDOOR CLIMATE

As part of the remaining medieval structures in the choir, of which there is otherwise only the outer aisle walls left, the vault was integrated into the rebuilding programme carried out between 1878 and 1890. The choir was then reconstructed to what it may have looked like in the 13th century (fig. 36).

Observing the painted vault and especially the wall above it (fig. 35), large amounts of salts can be seen. The salt originates from 19th century masonry materials through which water collecting at the flying buttress and in the lower parapet outside penetrates. 19th century masonry in this part of the cathedral is mainly built from Grytdal stone – a stone known to produce significant amounts of gypsum and magnesium sulphates upon oxidation of its pyrrhotite (iron sulphide) and subsequent chemical reactions.\(^\text{13}\)

\[\text{Figure 35: The top of the painted vault is covered with a layer of cement. Note the salts on the wall and the pipe providing hot water for the cathedral’s heating system}\]

\(^\text{13}\) See description of the general weathering situation at the choir in Storemyr 1997:207ff
Since the outside parapet was covered with copper plates in the 1980s, the frequency of water leaks affecting the murals must have been strongly reduced and there has been no recorded events of leaks since then.

Water leaks are possibly not the only moisture source at the vault – condensation may also play a role. However, as can be seen from the climate diagram in fig. 38, the potential for condensation is extremely small, chiefly because the vault is situated wholly within the building. In the winter, as the cathedral is heated to almost 20°C, the dew point is at −5 to +5°C, whereas by summer temperatures at 20°C, it is at maximum c. 13°C. Thus, it seems that only extremely humid summer days can give rise to condensation at the vault. The nearby masonry of the aisle, including the window, is, however,
potentially more endangered, as it is generally cooler and may thus be subjected to condensation both in winter and summer. But as the thermography recording in fig. 37 shows, the masonry around the window had a temperature of c. 10-12°C in March 2002. These wall temperatures were too high for condensation to take place at that time.

Figure 38: General climatic conditions in the Nidaros cathedral, as exemplified by the North Transept and the year 1998. This diagram is also more or less valid for the choir. It can be seen that during heating in the winter, the temperature and relative humidity are 17-20°C and 20-40%, respectively. In the summer, the temperature is almost the same, but the relative humidity may rise to nearly 70%. See also Storemyr & Nørsett (2000) for a description of the indoor climate.

WEATHERING FORMS ON THE PAINTINGS

The weathering forms on the paintings at the vault have been mapped in detail (appendix 4). Below, each of the mapped forms, as well as additional features, will be described. The mapped forms only include those apparently still weathering actively. Old damages, especially those related to uneven and fragmented plaster and paint, were not mapped. It should be noted that no old fire-damages have been observed.

Cracks and fissures

There are chiefly two types of cracks and fissures in the vault. The larger cracks are related to structural failure of the choir$^{14}$ and to be found along the borders of different cells and between cells and ribs. In cell V_N (fig. 15, 16), they have at some occasion been repaired with Portland cement mortars, but have later partly reopened (fig. 39). Smaller cracks and fissures cut through the paintings, but these appear in general to be old and not particularly dangerous (fig. 41). In cell V_N one crack that is cutting through the middle of the painting has been repaired by Portland cement mortar (fig. 40).

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Figure 39: Structural crack in cell V_N repaired with cement mortar, which has later reopened. Photo no. V_N_Det_06.

Figure 40: Crack, possibly structural, in cell V_N. The crack has been repaired with cement mortar. Note white salt efflorescences (epsomite) in the lower right part and pencil strokes around the red paint. Photo no. V_N_Det_05.

Figure 41: Thin fissure in cell no. N_V. This is an old fissure, probably not active anymore. Note also darkened green painting and salt crusts. Photo no. N_V_Det_06.

Figure 42: Cracked plaster from the restoration in the 1880s, partly covering a tendril. Note the fragmented green and that plaster and whitewash at many places were not properly removed in the 1880s. Photo no. N_V_Det_05.

Figure 43: Salt efflorescences and crust, particularly related to disintegration of with haematite red paint. Note also salt below exfoliating limewash in the upper left part. The salts are mainly epsomite. Photo no. N_V_Det_02.

Figure 44: Fragmented, but mainly stable paint layer with a very rugged surface. This surface phenomenon is caused by cauliflower-like gypsum crusts within the paint layer. White crusts mainly consist of epsomite. Photo no. N_V_Det_04.
Hollow areas
Especially in cell N_V there are several hollow areas, whereas in cell V_N there is only one large. These are generally located below the plaster or between older layers of plaster. The areas do not seem to be acutely endangered and no stabilisation measures (injection) were considered necessary.

Upper plaster away (stable)
This is not really a weathering form, but it was included during the mapping because of its tendency to make the painting look fragmented and uneven. It can be found in several areas, especially in cell N_V, in which an upper plaster layer was removed, or weathered away, before the paint was applied.

Active exfoliation (limewash)
Active exfoliation of limewash, with or without paint, is not very common. At those few places in which it occurs (see example in fig. 43), there is always salt behind the flakes that are about to loosen (see below).

Salt on paint, often with disintegration
Salt is distributed throughout the paintings, but readily visible, fluffy white crusts are especially connected with the red hematite paint constituting the second paint layer of the tendrils. At many places this red paint is completely disintegrated (fig. 43, see also the cover photo) and more or less lost. Analyses show that the readily visible salt is always epsomite (MgSO₄•7H₂O), sometimes probably dehydrated to hexahydrate (MgSO₄•6H₂O) (see appendix 1). In addition, gypsum is present in the paint layers.

Salt efflorescences and crusts
Various forms of salt efflorescences and crusts are distributed throughout the paintings. One form is the fluffy crust described above, another is a “glassy” variety of the same crust, possibly representing another crystallisation phase. However, the most common salt is gypsum, widely distributed on the paintings as hard-to-see cauliflower-like crusts, often within paint layers (fig. 22, 27, 28, 44). In many cases it appears that this crust actually has a consolidating effect on the paintings. However, this possible consolidating effect is of course only maintained as long as no water (also connected with condensation) influences the paintings.

Dirt and dust (not mapped)
Relatively loosely bound dirt and dust, and some cob webs, covered most of the paintings, as well as the cells that are not painted and surrounding stonework. At many places such dirt and dust is also integrated in the extensive gypsum crusts. The main reason for the accumulation of airborne dirt and dust ought to be the strong indoor heating and the fact that this part of the cathedral has not been properly cleaned since the main restoration phase in the 1880s. This was also the reason why the indoor cleaning programme for the whole choir was launched in winter/spring 2002.
Fading and darkening of green paint (not mapped)
The fading and darkening of the green paint were mentioned in chapter 3. It seems very strange that the same paint layer is subject to both phenomena, and a satisfactory explanation for this has yet to be found. In some cases it would seem that the darkened green paint, possibly containing copper oxide (tenorite), is concentrated to layers still hidden by later limewash, whereas the fading paint can be found in exposed locations. More research is definitely needed, and it should for instance focus on how the large amount of sulphate on the paintings reacts with green verditer.

Pencil strokes (not mapped)
The numerous pencil strokes found on the paintings are, as mentioned in chapter 3, probably related to reconstruction attempts in the 1880s. The strokes must be regarded important historical features, adding to the value of the paintings.

SUMMARY AND DISCUSSION OF WEATHERING PHENOMENA
Except for disintegration of some paint layers obviously related to large amounts of epsomite, as well as some active exfoliation of paint layers and limewash also related to salts, the paintings are astonishingly stable at the moment. With these huge amounts of salt present, one would have expected that the paintings had been in a state beyond repair and conservation.

Paradoxically, it appears that gypsum, mostly present as cauliflower-like crusts within the paint layers, actually contribute to the preservation of the paintings. This is because gypsum keeps the paint together, given that no water leaks occur – and this seems to have been the case since the covering of the outside parapet, from where leaks would have occurred, with copper plates in the 1980s. This also means that most of the damages – and the salt – to be observed today developed before the 1980s. Moreover, the readily visible epsomite is not as dangerous as it might seem because of the rather stable climate within the cathedral. The vault is for instance rarely subject to condensation events.

Theoretically, epsomite is stable at a relative humidity above c. 85% only (at c. 18°C). Below this value it should lose some of its crystal water and occur as hexahydrite (until c. 60%), starkeyite (until c. 30%) and kieserite.15 Obviously, these theoretical values do not apply to the vault in the choir, as epsomite was found at a relative humidity of 30-40% in March 2002. Generally, this might imply that the actual stability range of epsomite at the vault is large, and thus that it does not cause as much damage as would be expected.

Cracks and fissures, as well as hollow areas below the plaster, are widespread at the murals, but apparently not very dangerous. However, this consideration only applies as long as the choir as such is structurally stable.

15 According to computer modelling using ECOS/SALT (Price 2000) and RUNSALT (Bionda 2002), and according to descriptions given in Bionda & Storemyr (2002).
6 Conservation measures

by Ann Meeks

Due to lack of time and the fact that the scaffolding was at hand for a short time only, the conservation measures were carried out more or less simultaneously with the investigations described earlier in this report. This implied that there was no time to profoundly evaluate the findings before measures were carried out. It also meant that the actual conservation measures were kept at a minimum – also because there was no time for extensive experimentation with various conservation means. Generally, the work must thus be regarded as an emergency conservation.

Measures related to both stonework and the murals on the vault’s cells are described below. Only cell N_V and cell V_N (see chapter 3) were treated, whereas cell O_S was left untreated. Measures related to the two cells are all documented on the photos in appendix 4. Photos taken after the conservation can be found below. Just after the conservation of the mural paintings the non-painted cells on the vault were restored by the Restoration Workshop of Nidaros Cathedral (fixing of cracks etc.). These measures are not described in this report.

**Cleaning**

Superficial dust was removed by very carefully brushing with a soft brush the dust particles into a vacuum cleaner. The mural is fragile in many places and the risk of attempting to remove the more solidified dirt is not justified.

The salt efflorescence was unsightly and covered much of the decoration. As much salt as possible was very carefully picked off with a sharp scalpel blade. It was necessary to consolidate (see below) and securing a few areas before removing salt because paint flakes carrying salts were separating from the substrate (exfoliation). Salts present as a hard thin layer (mainly gypsum crusts) were not removed completely as there was a risk of damaging the paint. The result of removing some salts gave the mural a more colourful and cleaner appearance.

Cleaning of soapstone stonework was more straightforward and was done using partly the same methods as for the rest of the choir. There were however more traces of paint to be found on this part of the building; cleaning was thus done carefully and only when absolutely necessary. Cleaning was
done using soft brushes / vacuum cleaner and Gumma paine (dough) a natural latex sponge. Areas near the window were very dirty with black soot and were cleaned with microfibrinous cloths moistened with synperonic N (surfactant; alkyl phenol ethoxylate, based on nonyl phenol) and neutralized with clean water.

**MORTAR REPAIRS**

Limewash and plaster had at places separated from the substrate, especially connected with cracks, leaving the edges vulnerable to further loss. At some places cavities (hollow areas) was located behind the plaster.

Lime putty (Rødvig wet-slaked, aged lime) was used to make up the mortar repair material, of which three different grades (fine, medium, coarse) were prepared and tested. Aggregates comprised local sand and quartz powder, whereas colour was achieved by small amounts of burnt umbra.

After the testing, the following mixtures were put in use:

Fine:  
2 parts quartz powder (0-300 µm)  
1 part sand  
1 part lime putty

Coarse:  
1 part quartz powder (75-150 µm)  
2 parts sand  
2 parts lime putty

The coarse stuff was used on areas with larger losses and the fine stuff on the finer cracks. Also finer stuff was used sparingly as support on areas where the limewash was fragile. The area concerned is found on the N_V section near the rib above the centre. Here there is a ridge up to a part that has missing limewash, but which is nevertheless painted.

**PENCIL LINES**

Pencil lines are drawn around the edges of the foliage in order to highlight the shapes of faded paintings. In some places the foliage is hardly seen, just an outline done in pencil. The pencil lines do not seem to have any damaging effect so they were therefore not removed. The pencil lines can also be regarded as part of the history of the mural, they are not unsightly and removing them could possibly cause some damage.

**CONSOLIDATION**

In several places the paint layers had separated from the substrate (exfoliation). It is clear that much of the paint had loosened and fallen off earlier. Salt has lifted up paint layers so that there was very little to keep them from separating completely. It was thought to be most likely that paint in such places would soon fall off and be lost if no action was taken to secure the
Figure 45: Cell N_V after conservation measures in March 2002.
Photo: Bruce Sampson /The Restoration Workshop of Nidaros Cathedral.
Figure 46: Cell V_N after conservation measures in March 2002.
Photo: Bruce Sampson /The Restoration Workshop of Nidaros Cathedral.
flakes. However, only in cases judged as urgent were loose paint flakes stuck back using Paraloid B72 (10% solution in ethanol) as sparingly as possible. Paraloid was injected with syringe behind the exfoliated area twice, pushed and held back with Melinex (polyester film) until fixed on the third application.

**MATERIALS AND TOOLS USED**

- Paraloid B72 (Ethyl Methyl Methacrylate)
- Lime putty (wet-slaked, aged lime from Rødvig)
- Finely ground quartz powder (from Deffner&Johann)
- Sand (local from Ramlo)
- Burnt Umbra (Pigment)
- Ethanol
- Melinex (polyester films)
- Gumma paine (dough mixed with sodium hydroxide and copper sulphate and baked in a microwave)
- Microfibrous cloths
- Synperonic N (surfactant; alkyl phenol ethoxylate, based on nonyl phenol)
7 Prognosis, monitoring and recommendations

As long as the choir remains structurally stable and no water leaks occur from the outside parapet, it is to be expected that the murals on the choir’s vault and the paint on stonework nearby will be kept roughly in the present state for a long time. However, occasional summer condensation events may give rise to dissolution and recrystallisation of the large amounts of prevailing salts, thereby contributing to further damage. Moreover, salt crystallisation related to changing temperature and relative humidity should not be excluded.

Possible summer condensation events and other salt crystallisation phenomena should therefore be monitored and evaluated in order to be able to find measures to reduce these risks. Moreover, for the coming restoration of the north façade of the choir, special attention should be paid to the risk of water leaks from the aisle parapet. Due to the elevation it is very difficult to directly monitor the evolution of the condition of the mural paintings on the vault. Thus, it would be advisable to once in a while use a moveable scaffolding to check the condition – first of all if new salt efflorescences are present.

Furthermore, it would be a good idea to remove all the salts on the wall above the vault as well (see fig. 35). In case water penetration should occur, these salts will be readily dissolved, possibly entering the mural paintings.

In the work described in this report it was not possible to find the exact painting technique used for paint on stonework, neither if binders other than lime is present on the mural paintings. Thus, it is recommended to take a few extra samples on the vault and undertake relevant analyses (as described in chapter 3). It would also be advisable to investigate whether the bleaching and darkening of the green paint layers have largely come to a halt or if the processes are continuing.

Such analyses could be part of a further programme for investigation of paint fragments in the cathedral. It is for instance *highly recommended to properly investigate the octagon with regard to paint before any kind of cleaning measure is undertaken.*
References


Distribution of the report

As a printed version to:
The Restoration Workshop of Nidaros Cathedral (3 copies)
Archaeological Museum in Stavanger (1 copy)

As PDF-file by E-mail to:
The Restoration Workshop of Nidaros Cathedral
attn: Øivind Lunde, Director (oeivind.lunde@kirken.no)
    Børge Aune, Head of Workshop Department (borge.aune@kirken.no)
    Rune Langås, Workshop Manager (rune.langaas@kirken.no)
    Øystein Ekroll, Cathedral Archaeologist (oeystein.ekroll@kirken.no)

Archaeological Museum in Stavanger
attn: Ann Meeks, Conservator (Ann@Ark.museum.no)

In addition, the report will be available for download at www.ecd.ethz.ch/regalia
## Appendix 1: Salt analyses

For location of samples, see appendix 4. Analyses undertaken by microscopic and microchemical means, see Arnold (1984)

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Description of sample</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>070302_01</td>
<td>Loose, salt crust on cement, one phase is glassy, the other more whitish/yellowish, not alkaline</td>
<td>Glassy phase granular, the whitish/yellowish has many elongated or prismatic crystals. The latter shows signs of ageing (dark spots, “holes”). Both phases consist of epsomite. The two phases probably represent two generations or crystallisation phases. No trace of sodium/potassium/calcium</td>
</tr>
<tr>
<td>070302_02</td>
<td>As 070302_01, not so much of the glassy phase</td>
<td>As 070302_01</td>
</tr>
<tr>
<td>070302_03</td>
<td>As 070302_01, but also much red pigments from a tendril</td>
<td>As 070302_01. The pigment is strongly red, nearly opaque. Probably hematite red.</td>
</tr>
<tr>
<td>070302_04</td>
<td>Salt and loose plaster brushed from a damaged area</td>
<td>Granular and prismatic crystals of epsomite.</td>
</tr>
<tr>
<td>070302_05</td>
<td>Fine salt powder brushed from the wall.</td>
<td>Granular crystals of epsomite</td>
</tr>
<tr>
<td>070302_06</td>
<td>Salt powder and small limewash flakes brushed from the wall</td>
<td>Granular crystals of epsomite, some gypsum</td>
</tr>
<tr>
<td>070302_07</td>
<td>Salt crust above green paint</td>
<td>Granular and prismatic crystals of epsomite. The latter shows signs of ageing as in 070302_01</td>
</tr>
<tr>
<td>070302_14</td>
<td>Salt powder, some pigments</td>
<td>Fine, irregular forms, seems like a dehydrated epsomite to hexahydrate or, alternatively, a primary epsomite crystallised under non-equilibrium conditions. No traces of Na and K.</td>
</tr>
<tr>
<td>070302_15</td>
<td>Salt crust</td>
<td>As 070302_07</td>
</tr>
<tr>
<td>070302_16</td>
<td>As 070302_14</td>
<td>As 070302_14</td>
</tr>
</tbody>
</table>
Appendix 2: Analyses – paint on stone

Analyses of stratigraphy and pigments were undertaken by polarising microscopy of crushed fragments in oil-immersion. In addition, a polished section was made of sample 110302_02 (see chapter 3). Location of sample 110302_12, see appendix 4.

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Photo (arrow = location)</th>
<th>Description and results</th>
</tr>
</thead>
<tbody>
<tr>
<td>110302_01</td>
<td><img src="image1.png" alt="Image of sample 110302_01" /></td>
<td>Flake of red paint above lime that appears to have run along the rib. The lime may be mistaken for a ground and is partly transformed to gypsum. The paint is red ochre possibly mixed with finely ground limestone. Beside the running lime it appears that the paint is applied directly on the stone, as it also covers uneven parts (small damages) of the stone.</td>
</tr>
<tr>
<td>110302_02</td>
<td><img src="image2.png" alt="Image of sample 110302_02" /></td>
<td>Flake of red paint on a rib and with a greyish material above the red. Below the paint is lime which looks like a ground (cf. chapter 3, fig. 33). It is, however, possibly remains whitewash also used on the cells of the vault. The paint is red ochre mixed with finely ground limestone (partly transformed to gypsum) and the greyish material above is probably secondary gypsum.</td>
</tr>
<tr>
<td>Image</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>
| 110302_03 | **Rib**  
Flake of yellow paint on a rib. Below the paint is lime which looks like a ground. It is, however, possibly remains of whitewash also used on the cells of the vault. The paint is yellow ochre possibly mixed with finely ground limestone, partly transformed to gypsum. |
| 110302_04 | **Dogtooth**  
Powder of red paint scraped off the dogtooth. The paint is red ochre possibly mixed with finely ground limestone, partly transformed to gypsum. The paint appears to be applied directly on the stone. |
| 110302_05 | **Rib**  
Powder of a loose, grey material scraped off the rib. The material looks like dirt, containing typical soot particles. However, there are also traces of the following pigments: charcoal black, yellow ochre and ultramarine (one grain only). This might indicate that the “dirt” hides an old, weathered paint layer.  
Yellow patches on the picture are dolomite in the soapstone, oxidised on the surface. |
| 110302_06 | **Dogtooth**  
Flake of yellow paint on a dogtooth. The paint is very coarse yellow ochre, possibly applied on a ground of finely ground limestone or limewash, which is completely transformed to gypsum. Alternatively, the ground originally consisted of gypsum. |
| 110302_07 | **Rib**  
Flake of red paint below old mortar repairs close to the boss. There is a ground of finely ground limestone or limewash and the paint is red ochre. This paint layer possibly belongs to another phase than the others. |
| 110302_08 | **Boss**  
Powder of red paint scraped off the boss. The paint is red ochre possibly mixed with finely ground limestone, partly transformed to gypsum. The paint appears to have been applied directly on the stone. |
<table>
<thead>
<tr>
<th>Sample</th>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>110302_09</td>
<td>Boss</td>
<td>Powder of yellowish to brownish paint scraped off the boss. The paint is red ochre possibly mixed with finely ground limestone, partly transformed to gypsum. The paint is applied directly on the stone.</td>
</tr>
<tr>
<td>110302_10</td>
<td>Boss</td>
<td>Powder of a loose, grey material scraped off the boss. The material looks like dirt, containing typical soot particles. However, there are also traces of the following pigments: charcoal black, yellow ochre and ultramarine (only one grain). This might indicate that the “dirt” hides an old, weathered paint layer (cf. sample no. 110302_05)</td>
</tr>
<tr>
<td>110302_11</td>
<td>Boss</td>
<td>Powder of yellowish to brownish paint scraped off the boss. The paint is yellow ochre possibly mixed with finely ground limestone, partly transformed to gypsum. The paint appears to have been applied directly on the stone.</td>
</tr>
<tr>
<td>110302_12</td>
<td>Rib</td>
<td>Powder of red paint scraped off a very weathered rib. The paint is red ochre possibly mixed with finely ground limestone, applied directly on the stone.</td>
</tr>
</tbody>
</table>

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Appendix 3: Analyses – mural paintings

Analyses of stratigraphy and pigments were undertaken by polarising microscopy of crushed fragments in oil-immersion. In addition, polished sections were made of samples 070302_08, 070302_09, 070302_10, 070302_11, and 070302_13. Location of samples, see appendix 4.

<table>
<thead>
<tr>
<th>Sample no.</th>
<th>Photo (arrow = location)</th>
<th>Description and results</th>
</tr>
</thead>
<tbody>
<tr>
<td>070302_08</td>
<td><img src="image1.png" alt="Photo" /></td>
<td>Strongly red paint, consisting of hematite red, apparently without any ground limestone as filler. Some secondary gypsum within the layer. Very fat limewash below, very little aggregates in the limewash.</td>
</tr>
<tr>
<td>070302_09</td>
<td><img src="image2.png" alt="Photo" /></td>
<td>Plaster from the 1880s (1). Probably a lime plaster, greyish because of the aggregates, approximate mix: 1:3. Above is a yellow limewash (2), also from the 1880s. The limewash is weakly yellowish, rather large, scattered grains of yellow ochre within. On the top is the grey wash from c. 1930 (3). This has been earlier interpreted as a cement wash, but is probably a limewash with scattered charcoal black pigments.</td>
</tr>
<tr>
<td>070302_10</td>
<td><img src="image3.png" alt="Photo" /></td>
<td>Red paint layer, covered by later limewash with a gypsum crust on the surface. Very fat limewash, also the one below. The paint is red ochre mixed with finely ground limestone.</td>
</tr>
<tr>
<td>070302_11</td>
<td><img src="image4.png" alt="Photo" /></td>
<td>Dark, slightly greenish paint layer, covered by later limewash with a gypsum crust on the surface. The paint is strongly altered green verditer, mixed with finely ground limestone. The brown patches on the picture might represent copper oxide (tenorite), formed in the alteration process of green verditer.</td>
</tr>
<tr>
<td>070302_12</td>
<td><img src="image5.png" alt="Photo" /></td>
<td>Strongly red paint layer on a fat limewash. The paint is hematite red in a crust of secondary gypsum.</td>
</tr>
<tr>
<td>070302_13</td>
<td><img src="image6.png" alt="Photo" /></td>
<td>Red paint layer, just beside a strongly red layer. The paint is red ochre, possible mixed with ground limestone. It has a gypsum crust and is found on a very fat limewash.</td>
</tr>
</tbody>
</table>
Appendix 4: Mapping of the mural paintings

Cell no. N_V:

1. Materials
2. Paint
3. Weathering forms / damages
4. Conservation measures March 2002
5. Samples of salt, mortar and paint 7.3.2002
6. Detail photos 7.3.2002

Cell no. V_N:

1. Materials
2. Paint
3. Weathering forms / damages
4. Conservation measures March 2002
5. Samples of salt, mortar and paint 7.3.2002
6. Detail photos 7.3.2002
Materials

- Fragments of limewash above coarse plaster (below paint)
- Fragments of two layers of limewash above paint
- Plaster (1880s)

Mapping/Conservation 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
**Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. N_V)**

Paint

- Dark red, much pigments
- Light red
- Green
- Orange (1880s?)
- Cement wash (c. 1930)

Mapping/Conservation 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Weathering forms / damages

- **Red**: Cracks and fissures
- **Green**: Hollow areas
- **Yellow**: Upper plaster away (stable)
- **Orange**: Active exfoliation (limewash)
- **Purple**: Salt on paint, often with disintegr.
- **Light Purple**: Salt efflorescences and crusts
- **Black**: Mortar pieces for analysis

Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. N_V)

Conservation Measures March 2002 (by Ann Meeks, AMS)

- Lime mortar repairs
- Loose paint layers stuck back with Paraloid B72
- All salt efflorescences and salt crusts removed mechanically

Mapping/Conservation 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. N_V)

Samples of salt, mortar and paint March 2002

- Red: Salt samples
- Green: Paint and mortar samples

Mapping/Conservation 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. N_V)

Detail photos 7.3.2002

Mapping/Conservation 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. V_N)

Materials

- Fragments of limewash above coarse plaster (below paint)
- Fragments of two layers of limewash above paint
- Plaster (1880s)
- Cement mortar repairs (cracks)

Mapping 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. V_N)

Paint

- Dark red, much pigments
- Light red
- Green
- Orange (1880s?)
- Cement wash (c. 1930)

Mapping 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. V_N)

Weathering forms / damages
- Cracks and fissures
- Hollow areas
- Traces of liquid cement
- Salt on paint, often with disintegration
- Salt efflorescences and crusts

Mapping 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. V_N)

Conservation Measures March 2002 (by Ann Meeks, AMS)

- Lime mortar repairs
- Loose paint layers stuck back with Paraloid B72
- All salt efflorescences and salt crusts removed mechanically

Mapping 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. V_N)

Samples of salt and paint 7.3.2002

Mapping 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Nidaros Cathedral, Trondheim, Choir Aisle, NE (No. V_N)

Detail photos 7.3. 2002

Mapping 6-14.3.2002
Per Storemyr (Expert-Center für Denkmalpflege) / Ann Meeks (AMS)
Appendix 5: Description of painted stonework in the vault

The Boss/Keystone
The ribs met up in a small ornamental boss with rotating foliage. It is made from soapstone and has a diameter of 33-34 cm and a height of 23 cm high (measured from the bottom to the line of where plaster begins on the vaults).

In the centre there is a round flat surface with an iron cramp in the centre. It is likely that here originally was fixed a carved rose or other flower in stone. The flat surface has traces of yellow paint, which means that the boss could have been re-decorated when the flower was already missing.

The carving is somewhat crude and has many signs of tool marks. There are also many secondary larger chips and damage seen as scrape marks, which look as if done at a later date. There are traces of red paint over the damaged areas. On the east side of the boss there is a hole pierced through a leaf measuring ca.15 mm (diameter). It has no traces of paint and is rather unevenly cut. The purpose of this hole is not known.

Red and yellow paint was found and a very thorough search did not reveal any signs of gilding. The four centre leaves are painted red and the rest of the carving is painted yellow with a few traces of red as well. This red paint does not seem to have any intended relation with the yellow paint on the carved leaves, as it is very sporadic.

The paint is found on the outer surface of the carving and only few traces are found in the hollows and undercuts.

The Ribs
The ribs were once painted. Especially the southeast rib has a good deal of red and yellow paint left

Red paint was found both on top of and under mortar splashes. Rendering of vaults causes a lot of mortar ending up elsewhere so this is nothing unusual. There were traces of yellow paint on the sides and on the dogteeth. It was not possible to fully understand the colour scheme, as red and yellow were found on all elements.

The Window
Much replacement stone is found in the window where no paint races will be found. Many of the original stones had traces of red paint on them. The earlier stones were in many places weathered and pitted. It was in the hollows of the pitting the red paint was found, which indicates that the decorating was done after weathering. There were no definite finds of original stones with original surface with original paint.

Ann Meeks