



WALLPAINTINGS OF DANGKHAR MONASTERY: INVENTORY AND APPROACHES TO CONSERVATION

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Contents

INTRODUCTION	<i>84</i>
I	
THE WALLPAINTINGS OF THE ASSEMBLY HALL ('DU KHANG)	<i>84</i>
II	
THE WALLPAINTINGS OF THE UPPER TEMPLE (LHA KHANG GONG MA)	<i>87</i>
III	
OUTLINING A CONSERVATION AND PRESERVATION STRATEGY	<i>89</i>
IV	
PHOTODOCUMENTATION, GRAPHIC RECORDING, ANALYSES REPORT	<i>92</i>

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INTRODUCTION

Field work 2011 and the outline of a wallpaintings conservation strategy

Scope of the field work in 2011 was to assess the wallpaintings of the monastery during a very first inspection in order to outline a wallpaintings conservation strategy within the SAVE DANGKHAR project frame (s. *Survey Report of the Ancient Monastery of Dangkhar*, Graz University of Technology, Institute of Architectural Theory, Art History and Cultural Studies, 2010).

With the field work 2011 an assessment and overall survey of the wallpaintings was undertaken to identify materials and painting technology of the murals, as well as to document and evaluate their damage patterns and the present state of condition (s. chapter I and II). Field work was focussed on the two most representative and also for visitors accessible interiors of the monastery decorated with significant wallpaintings: The *Dukhang* ("Assembly Hall") on the first storey of the monastic building complex and the *Lhakhang Gongma* ("Upper Temple") located separated from the monastery building above a cliff.

The wallpaintings assessment was based on visual diagnosis and on-site tests, and got further supported by scientific laboratory analyses. Its documentation was performed with photographs and digital mapping through recording selected assessment criteria (s. chapter IV).

Assessment and documentation of the Dangkhar wallpaintings followed the methodology chosen for the Nako site (s. *Nako Project reports 2004-2010*, University of Applied Arts Vienna, Institute of Conservation, 2004-2010), adapted to the limitations in personnel and time at the first inspection within the 2011 Dangkhar field work campaign.

Field work and subsequent scientific analyses results served as the essential base for establishing two suitable approaches for the conservation of both interior temple decorations and setting up a practicable conservation program to be implemented for the coming years (s. chapter III). For starting this, a small team of professionals supported by students (in total 4-5 persons) is foreseen to undertake the next conservation campaign in Dangkhar in summer 2012 in close collaboration with the architects team.

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I WALLPAINTINGS OF THE ASSEMBLY HALL ('DU KHANG)

Description: The wallpaintings

The wallpaintings of the *Dukhang*, located on the first storey of the Dangkhar monastic complex, are considered being the oldest preserved murals of the monastery and are related to the 15th ct. Among others, they feature a protector deity left to the entrance east wall and a *Green Tara* is flanked by *Atisa* and his disciple *'Brom ston pa* on the north wall. Today only three partly decorated walls are visible, as the rear west wall of the *Dukhang* is completely covered by a wooden library and glazed cabinet-altar. During field work 2011 the cabinet-altar construction got opened by the *Sangha*. Thanks to this, a very first and noticeable look at the wallpaintings behind could be undertaken by the architects and conservators team. In contrast to the three visible walls the usually covered rear wall exhibits a rather complete painted overall decoration.

The paintings are executed in a secco technique¹ on earthen supports. On the three uncovered walls they are preserved in a fragmentary state, decorating nowadays only parts of the assembly hall that measures approx. 7 x 7,5 m with 2 m in height.

On the occasion of the temporary dismounting of the central altar the three polychrome clay sculptures, part of the altar, got documented and cleaned as a preliminary conservation intervention.

Assessment focussed on the three visible and accessible painted walls.

Assessment: Visual diagnosis, on-site tests and laboratory analyses

Criteria to assess the historical structure were set up with:

- First plaster phase
- Re-plastering and repairs
- First and second painting phase

Laboratory analyses clarified questions on:

- Painting technology
- Palette of pigments used
- Binding material used
- Ground and supportive plaster layers

Parameters to survey the murals damage patterns and condition covered:

- Voids
- Cracks within masonry and plasters
- Losses of ground and paint layers
- Washouts and deposits in form of drips
- Flaking and chalking of paint layers
- Thinned painted surfaces
- Stains on painted surfaces
- Visible water horizons
- Earthen deposits on painted surfaces
- Soot and dust

¹ „Secco“ and „fresco“ name two principle wallpainting techniques. In the fresco technique colours are applied on the still „fresh“ plaster that has not dried; a process that enables the pigments to become part of the walls plaster itself. In contrast to this, secco paintings are applied on a dry plaster surface.

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On-site tests addressed:

- Wall surface temperature
- Plaster surface resistance
- Plaster surface conductivity (indicating moisture and/or water-soluble salts) and presence of salts
- Practicability of conservation measures

Inventory: Assessment results

Historical structure:

- First plaster phase

The first plaster phase was visible on the north wall, adjacent to the wooden cabinet, where big parts of the wall-paintings are detached, as well as only partly on all other *Dukhang* walls.

- Re-plastering and repair

Fully re-plastered areas are found on the right half of the north wall continuing on the left side of the entrance wall. Partial plaster repairs could be located on the north and east wall being partly covered with a unifying beige coating. In total, approx. 60-70 % of the three visible interior wall areas show plastered or repaired surfaces.

- First and second painting phase

Fragments of the first wallpainting decoration phase are found on the right side of the entrance wall featuring *Ma-hakala* depictions. On the south wall fragments of the first wallpainting phase are visible, but due to the little remnants left no iconographic analyses could be undertaken.

On the west wall, wallpaintings cover almost the whole wall area. The west wall partly revealed in summer 2011 showed that almost the whole wall is still covered with murals featuring a central *Buddha* image. As the cabinet was not removed, a detailed assessment could not be carried out. Compared with the other walls of the *Dukhang* the West wall paintings are not that fragmentary. The extent of the murals still preserved on the west wall can be explained by the covering and therefore protection by the cabinet construction.

Roughly estimated, painted surfaces of the three visible wall areas today make only 30-40 %.

Murals showed a white ground layer on which the paint layers were applied. On parts of the north wall paintings, a glossy surface was visible. Further, on areas of the *Green Tara* depiction a second paint layer got detected that in technology and artistic style matches with the first painting phase. There was no further second painting phase noticeable. Though, for the west wall this evidence has to be proved with a detailed future assessment.

Scientific analyses were based on this first on-site inspection and should clarify main issues of the painting technique applied: The palette of pigments and binding media used, the stratigraphy of support, ground and paint layers, as well as technological specifics.

Painting technology:

In general the scientific analyses of the samples confirm a traditional painting technique characteristic for this area. The painting technique is a secco technique, thin paint layers are bound with animal glue and are executed over a white gypsum ground. Binder of the gypsum glue is also animal glue mixed with starch. Based on the pigment identification it is not possible to give an exact dating of the murals – there were not found any pigments that allow the dating.

Interesting are the results of the study of the sample from the west wall [sample 608 (01D)]. The paint layer and the ground are executed on the earthen plaster that contains also various pigment grains – vermilion, azurite, orpiment. These pigments highly probably originate from the older painting that is/was underneath the today visible painting. By application of the secondary plaster (this means the plaster from sample 608) the surface of the original water-soluble paint-layers (probably bound with animal glue) was wetted and partly destroyed and the pigment particles were partially transported to the newly applied plaster.

In other words this could mean that the today visible painting is very probably not the original one. At the moment the result could not be further interpreted without verification of more samples. There could be two possibilities:

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On the one hand it could mean that there has been an older painting phase on the whole west wall or even in the whole *Dukhang*. On the second hand it could also be the result of partial repair work. To prove this, further analyses have to be done in future campaigns.

In one sample from the *Green Tara* from the north wall two paintings from two different periods were confirmed. Both, the earlier and the later painting are bound with the animal glue. Also here, further investigations have to be done to give more detailed information and allow appropriate interpretation.

Damage patterns:

- Voids

Voids within the paintings supportive earthen structures were investigated to be mainly located around crack lines, under the load-bearing wooden roof construction and going along with wall openings. Voids make losses of adhesion within the plaster and masonry structures evident. Causes may be diverse and commonly combined: Material technology as well as mechanical stress, water, temperature and salts.

- Cracks within masonry and plaster layers

Cracks were located on the north, east and south walls. Cracks appear in form of single vertical and horizontal crack lines as well as in crack systems. The latter mainly occur within the plaster and not in the masonry. Cracks were related to mechanical stress resulting from immediate earthquake forces as well as permanent loads and continuous setting of the building structure. Further, micro-crack systems within the paint layers were discovered throughout the painted surfaces.

- Washout and surface deposits in form of drips

Washout was detected on the right side of the east wall indicating a former water infiltration by roof leakage. Washout on earthen supports usually appears in connection with deposited earthen drips on adjacent areas and extant losses of water-soluble paint layer areas. Characteristic deposits on painted surfaces in form of drips occur on the east and south walls.

- Losses of ground and paint layers

Losses of ground and paint layers are found on all the three walls assessed. Despite the main loss of painted surfaces on the re-plastered walls already mentioned, bigger losses of ground and paint layers occur on areas above the ground and below the ceiling. Damage causes can be described by rising damp, especially in connection with water-soluble salts that were identified on the north and east walls, as well as by mechanical stress through the load-bearing roof. Areas with clusters of smaller losses could also be located on all the three walls. E.g. on the *Green Tara* clusters of smaller losses might just concern paint layers: Here, the ground is still visible and attached to the plaster support. Losses of paint and ground layers are attributed to result from major flaking leading to detachments of the single layers.

- Flaking and chalking of paint layers

Flaking of paint layers was discerned on all the three *Dukhang* walls, especially in the centre areas of the walls. Flakes form a characteristic *craquelée* pattern and might detach at their edges resultant from a lack of adhesion to the ground layers. Flakes dimensions range from 5 mm up to 35 mm.

Chalking was not evident on the *Dukhang* paintings.

- Thinned painted surfaces

Thinned painted surfaces were noticed at the east and south wall areas from the ground up to a height of 80 cm. Thinning might be caused by continuous mechanical abrasion possibly related to ritual use.

- Stains on painted surfaces

Stains were not detected.

- Visible water horizons

There were no water horizons visible on the *Dukhang* interior walls.

- Deposits on painted surfaces

Deposits on painted surfaces appeared in form of splashes and dots of different sizes. They might stem from later repairs or water infiltration, mainly consisting of earthen materials.

- Soot and dust

Dark soot and dust layers were present on all the *Dukhang* walls, these phenomena could also be inspected on the west wall. Dust layers were either compacted or loose. Soot and compacted dust generally occur together and

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are hardly to be differentiated. Soot is usually caused by the ritual use of butter lamps, its greasy and sticky surface helps dust to be absorbed.

All phenomena and findings described were photographed and compiled in a representative photo documentation (s. chapter IV). Complementary to this qualitative approach in documentation, the graphic mapping provides a quantitative overview of the assessment parameters that also allows a rough estimation of their extent (s. also chapter IV).

Supported by on-site tests that are described below the condition survey could be concluded. With it, a basic evaluation of the present state of condition, an explanation of damage causes, and the need of conservation actions could be outlined (s. end of chapter I).

Wall surface temperature:

Generally speaking, thick walls made of earthen fabric like in the Dangkhar monastery serve as ideal thermal buffers that usually guarantee a very stable interior climate for the painted decoration. Wall surface temperatures measurements in the *Dukhang* showed the typical and rather modest increase of temperature with the height of the wall. There was a considerable difference between the north and south wall surface temperatures. Lowest temperatures were measured on the north wall in the corner that is close to the rock behind, which gives an explanation for the rather low temperature results. The south wall directly exposed to the exterior climate conditions showed – not surprisingly – the highest surface temperature values.

Plaster surface resistance:

Unpainted plaster surfaces indicated different grades of resistance. Resistance depended on the type of plaster (original or later repair) as well as on the degradation of the plaster. Scaling on mainly original plaster surfaces could be related to moisture and/or the presence of salts, and was found on areas above the floor. Sanding was found on all unpainted original and later plaster surfaces.

Plaster surface conductivity and presence of salts:

Scaling plaster surfaces and high surface conductivity results are linked to increased moisture content and the possible presence of water-soluble salts. Earthen plasters are highly porous materials that are not resistant to direct water contact and allow rapid water uptake through capillarity, as well as sorption and permeability of water vapour. This further leads to the presence and transport of water-soluble salts. Plaster areas above the floor usually show higher moisture content due to rising damp. In the rather moist zones in the left corner of the north wall as well as on the east wall above the floor nitrates as well as chlorides were found, sulphates could not be identified.

Conclusion: Damage causes/risks, state of condition, the need of conservation actions

Damage and decay phenomena in the Assembly Hall highlight two decisive damage causes: mechanical stress (resulting from moving and setting of the building, seismic forces) and water. Both factors can be related to the architectural structure itself as well as to the properties of the earthen building fabric, and its maintenance and use.

Earthen materials in general show low strength properties and are not resistant to water. Therefore, regular building maintenance including efficient protection against direct water infiltration is essential for the preservation of earthen architecture: This fact needs further attention if earthen buildings house artistic interior decorations and even more, if the decorations, as in Dangkhar, are highly water-sensitive.

Considering the long building history of the Dangkhar complex – parts and storeys of the monastery are assumed to have become subsequently added – several hypotheses to explain the enormous

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losses of murals become likely. One can think of scenarios, when parts of the north and east walls or of the roof (that now serves as an intermediate ceiling) were damaged during reconstruction or even collapsed.

However, the condition of the still preserved murals in the *Dukhang* can – generally speaking – be described as relatively stable with respect to the building envelope and adhesion to the temple walls.

At present, the building envelope seems to be tight and under moderate conditions protective against water. Here, one has to take into account the ongoing regional climate change that comes along with unpredictable disasters like heavy rainfall and flooding as in summer 2010, as well as the geological setting of Dangkhar in a highly seismic zone. These facts together with the complex architectural situation make it hardly impossible to give a sensible statement on possible risks or future threats.

What can be stated is, that there was no severe adhesion problem of the paint layers, the ground and the supportive plasters evident. It has to be added though that there are considerable voids within the masonry indicating losses of adhesion between single masonry components. For a detailed condition report – including the rear West wall that is usually covered by the wooden construction of the library and altar – further field work needs to be carried out.

The aim of an overall conservation program has to address the long-term stabilisation and consolidation of the wallpaintings that further losses and decay can be avoided as far as possible. Conservation measures for the painted areas are to include the cleaning of the surfaces, the consolidation of paint layers as well as filling of cracks and losses, and the backfilling of voids mentioned. Additionally, the aesthetic integration of the wallpaintings within the particular interior context needs to be approached. The aesthetic integration will have to present the fragmentary murals of the *Dukhang* as one of the main and most important monastery rooms that is open and attractive to the visitors.

As noted, movement and setting of the architectural structures poses a considerable risk to wallpaintings. During the planned general architectural restoration of the Dangkhar monastery movements of the very complex buildings structures will inevitably take place. Therefore the permanent accompanying support of conservators has to be provided: This concerns not only the *Dukhang* but other chapels' interiors as well (s. chapter III).

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II

WALLPAINTINGS OF THE UPPER TEMPLE (LHA KHANG GONG MA)

Description: The wallpaintings

The wallpaintings of the *Lhakhang Gongma*, situated outside the monastery, elevated on the cliff behind the building complex and reached by an outside path and stairway, feature: Protector deities flanking the entrance door and a life-sized central *Buddha* with *Tsongkhapa* and *Atisa* to his both sides on the rear southwest wall. The other walls present life-sized *Medicine Buddhas*, with four *Buddha* depictions on the Southeast and four *Buddhas* on the opposite northwest wall. With exception of the entrance wall, a frieze with the *12 scenes of Buddha's life* goes along all the lower wall areas. The original paintings program is related to the 16th ct.

What is immediately noticeable to the visitor of the temple and what was especially brought up to the conservators team are the very colourful – partly – over-paintings of the figure depictions on all the walls.

In contrast to the fragmentary *Dukhang* murals, painted decorations in the Upper Temple cover almost completely the temple walls. Original as well as later paintings are executed in a secco technique on earthen supports. Painted wall areas measure approx. 5 x more than 3 m in height each.

Scope of the assessment in 2011 was performed analogue to the *Dukhang* wallpaintings survey, but with an emphasis on the treatment and conservative approach of the later over-paintings. All the four walls of the Upper Temple got assessed.

Assessment: Visual diagnosis, on-site tests and laboratory analyses

Parameters to assess and analyse the historical structure, painting technology, and present state of condition of the *Lhakhang Gongma* murals were set up according to the assessment methodology in the *Dukhang* (s. chapter I). Assessment and analytical methods were selected and performed similarly.

Inventory: Assessment results

Historical structure:

- First plaster phase

The first plaster phase showed a smoothened surface to serve as an even support for ground and painting layers of the first wall painting decoration.

- Plaster repairs

Partial repair plasters were noticed on all the temple walls. They were found on the skirting zone below the secondary painting, within the frieze remaining uncoloured or being whitewashed, and below single zones of the secondary painting phase. In principle, cracks were plastered and repaired before applying the secondary wall paintings. However, main parts of the second paint layers were directly applied on to the first painting surfaces without any re-plastering.

- First painting phase

Preserved extant parts of the first wallpainting decoration phase were found on all the temple walls. More or less the whole frieze going along all the walls despite the entrance wall from approx. 50 to 80 cm up the ground features a first painting phase. On the entrance walls the whole left side, the area above the door and the uttermost right side of the wall go back to the first painting phase. On the adjacent southeast wall the first *Buddha* from the left, almost the whole fourth *Buddha* from the left, as well as nearly all of the *1000 Buddhas* depictions in the background of the whole wall above the frieze stem back to the first painting phase. On the upper rear wall more or less the whole central *Buddha* and parts of his surroundings were painted in the first phase identified. Above the

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frieze, the northwest wall shows the first and fourth *Buddha* from the left, main parts of the surrounding background depictions, and the main corpus of the third *Buddha* to be painted in the first phase as well.

- Second painting phase

Second painting phase layers are visible on the right side of the entrance wall; the protector deity *PaldenLamo* and the surroundings on the left and upper part belong to this phase. The decorative lines around the entrance door and throughout all the walls skirting zone are painted in a second phase, as well as the upper borderline of the frieze. On the Southeast wall the second *Buddha* from the left, the third one and two smaller background figures of the *1000 Buddha* motive above the third *Buddha*, two animals in the painted curtain below the ceiling, and parts of the fourth *Buddha*, mainly his skin, are secondary paintings. The southwest wall shows mostly the central *Buddha* depiction and two vertical stripes on his sides from the beams down to the frieze are painted in a second phase.

Second painting phase layers are further recognized on the northwest wall. Here, the second *Buddha* from the left, and almost the whole background area from the ceiling down to the frieze, the lower background motives of the first *Buddha*, the lotus seat, head and *Mandorla* of the third *Buddha*, as well as some parts of the fourth *Buddha*, in the main his skin, are later paintings. The second *Buddha* also presents a glossy surface covering the lotus seat, the *Buddha* figure and the *Mandorla*.

What should be remarked is that the secondary paintings in many cases follow the outlines and motives of the first painting phase in a very distinct way. Taking a closer look, one can find many detailed illustrations, such as the *Buddha's* attributes, palms and soles, wardrobe patterns, and also parts of the background figures still left from the first painting phase. Further, outlines from the first phase were kept and followed, the inner painting areas being generously re-coloured.

Painting technology:

In the *Lhakhang Gongma* the painting technique also follows the traditional way of secco painting using animal glue as a binder. Paint layers are executed on a white gypsum ground layer containing a mixture of starch and animal glue as a binder. Dating of the paintings based on the pigment identification is not possible.

In sample 605 (02 U) also the second painting phase was found. Binding medium of the secondary phase is again animal glue. Due to the pigments used in this phase – chrome yellow and barite – it can be said that the second phase must have been applied earliest in the nineteenth century (as chromium containing pigments were discovered at the beginning of the nineteenth century).

The over-paintings of the second layer are applied over the first phase which can be seen very clearly. However, this does not mean that under all over-paintings original murals could be found. Further analyses should follow to get more detailed knowledge about the two phases.

In the zone with the frieze with paintings of the first phase a thin transparent organic layer was found indicating a previous conservation treatment [604 (07 U)].

As mentioned, also for the *Lhakhang Gongma* further investigations have to be done to receive specific information about the different paint layers and previous conservation treatments undertaken.

Damage patterns:

- Voids

Voids within the paintings supportive earthen structures were noted in connection with crack lines, under the load-bearing wooden roof, as well as not related to any further damage patterns or structural elements being located in the centre of the walls or in the frieze areas. Voids result from a lack of adhesion within the plaster and masonry structure with the diverse causes already mentioned: material and technology, mechanical stress, water, temperature and salts.

- Cracks within masonry and plasters

Cracks are found on all the walls. Cracks occur in form of single vertical lines that often reach over the whole height of the walls, in horizontal lines as well as in crack systems. Cracks are visible in all the four corners, and also here going down from the top to the bottom. It was recognized that in some of the main cracks within the masonry air from the outside could go in. Also in the *Lhakhang Gongma* cracks are related to mechanical stress resulting from earthquakes, loads and setting of the building structure towards the West. Compared with the *Dukhang* in the *Lhakhang Gongma* the problem of cracks seems to be more evident.

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- Washout and surface deposits in form of drips

Washout was recognized on the southeast wall above the second *Buddha* from the left, it occurs together with voids and deposits in form of drips. On the southwest wall washout appears above the central *Buddha* depiction as well as above *Tsongkhapa* to his right. Also here, deposits in form of drips were found. In the case of *Tsongkhapa* extant flaking goes with the fluted areas. By these phenomena a former water infiltration through leakage in the roof can be assumed. Characteristic deposits on painted surfaces in form of drips were documented on all the walls, mainly in the upper areas. It was recognized, that drip-like deposits not just started directly below the ceiling, but within open crack lines. Most of these deposits were assessed to be on the southeast wall.

- Losses of ground and paint layers

Losses of ground and paint layers are found on all the four assessed walls. Major losses were recorded under the roof on the southeast and southwest walls; on the Southeast wall a distinctive area with losses was found above the floor. Besides these major single losses, clusters of smaller losses ranging from 10 mm to 80 mm each were surveyed on all four walls.

These clusters appear in combination with cracks and flaking areas, and partly along the voids. Detachments of ground and paint layers are related to loss of adhesion that might be caused by mechanical stress as well as a consequence of flaking and surface cracks.

- Flaking and chalking of paint layers

Flaking of paint layers was documented on all the four walls, mainly within the frieze and on the rear wall: Here to be visible to an increased degree. Smaller flaking areas were found on the first *Buddha* from the left together with his background depictions and on the fourth *Buddha* from the left on the southwest wall, primarily in his skin. Flakes reveal a characteristic – compared with the *Dukhang* slightly bigger in size – *craquelée* pattern and might detach on the edges resultant from a lack of adhesion to the plaster layers. Flakes dimensions range from 10 mm up to 45 mm, what was noted is, that flakes with detached edges comprise of paint and ground layers. There was no flaking of paint layers existent off the ground.

Chalking was not evident on the *Gongma* wallpaintings.

- Thinned painted surfaces

Thinned painted surfaces were visible on all wall areas from 50 cm, the repainted bottom banner in the skirting zone, up to a height of 80 cm; meaning in general the whole frieze running horizontally along the lower temple walls. Because of thinning an overall underlying orange paint layer got visible on the frieze, as well as in some areas on the first painting phase above. Thinning might be caused by continuous mechanical abrasion possibly also related to (ritual) use.

- Stains on painted surfaces

Stains were detected within the frieze in form of characteristic dots with a diameter of 7 mm to 10 mm. Dot-shaped stains were further recorded in the *Mandorla* of the fourth *Buddha* from left on the southeast wall, as well as on the southwest wall in the inner *Mandorla* of the *Atisa* depiction. If the stains result from ritual use, waits to be investigated. A natural cause for the staining in the lower parts of the walls seems to be unlikely.

- Visible water horizons

There was one water horizon visible on the southeast wall stretching from the left corner on the bottom to the centre of the wall with a maximum height of approx. 30 cm. The water horizon is accompanied by a major loss-area below and the presence of water-soluble salts. The damage phenomena might go back to the outer building situation where a base is built up on the bottom part of the wall.

- Deposits on painted surfaces

Deposits appear in form of splashes and dots of different sizes on all painted surfaces, they accumulate on the whole left side and the uttermost right side of the Northeast wall, as well as throughout the frieze and on the first *Buddha* from the left on the southeast wall. They presumably result from later repairs or water infiltration, and generally consist of earthen materials.

- Soot and dust

Despite above the altar area below the central *Buddha* on the rear wall there was no soot visible on the painted surfaces. Dust layers are visible on all the walls, showing both forms, compacted and loose.

Also in the Upper Temple, phenomena and findings were compiled in a comprehensive photo documentation; again, the graphic mapping helps to illustrate the extent of the phenomena recorded (for both s. chapter IV).

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Wall surface temperature:

Compared with the *Dukhang* walls, surface temperature results in the Upper Temple showed a minor distribution of values. Again, the characteristic increase of the surface temperature from bottom to the top of the interior walls was confirmed. Not surprisingly, northeast and northwest wall surface temperatures were slightly lower than southeast and southwest wall results. In general one has to state that despite the extreme exposure of the temple building to the outer climate conditions the interior wall surface temperatures are stable and do not show any extreme distribution of values.

Plaster surface resistance:

Scaling plaster surfaces indicating a rather low surface resistance were evident on unpainted plaster areas above the floor. In contrast, visible plaster areas below the ceiling showed almost no sanding surfaces and proofed to be compact and quite resistant to abrasion. The lack of resistance could again be directly related to an increased moisture content (on the bottom due to rising damp as well as the base on the outside Southeast wall) combined with the presence of water-soluble salts.

Plaster surface conductivity and presence of salts:

High plaster surface conductivity results and the evidence of salts present got very obvious on the southeast wall where a water horizon was visible. Nitrates, sulphates, and chlorides were found on the rather moist wall area that already lacks any painted surface. The three other walls of the temple do not show a comparable damage phenomenon above the floor. As mentioned before, the southeast wall moisture and salt damage is directly linked with the outer situation where, through the base, an increased water transport process gets initiated.

Conclusion: Damage causes/risks, state of condition, the need of conservation actions

Damage and decay phenomena in the *Lhakhang Gongma* confirmed the observations of the *Dukhang*: Also here, mechanical stress and water might be considered as the two most distinctive damage factors. Tracing back their causes, again one has to address the building, building materials, as well as maintenance and use.

The general building situation and its history is very different to the *Dukhang*. The Upper Temple is not incorporated into the complex architectural structure of the monastery and did not undergo the assumed subsequent construction phases of the monastery. With its position on the very top of the cliff the single-room temple is considerably exposed to the extreme outer conditions. This enhances the risk of natural disasters as noted in context with the *Dukhang* (s. chapter I)². The building envelope seems not to be completely tight and protective for the interior decoration: This is indicated by the active moisture damage on the southeast wall as well as cracks with air coming in.

When giving a statement on the present state of condition of the murals one needs to refer to the first and second painting phase separately. Concerning the first painting phase one can describe the general state of condition as fair to middling. The principal problem can be found in the loss of adhesion between paint and ground layer, and paint and ground layers to the supportive plasters respectively. Large areas of the original murals, especially on the rear northwest wall seem to be endangered to detach from the wall. Here a need for action is definitely given.

The second painting phase is considered to be in general in a better condition due to the repair measures that had been necessary before the second paint layer was applied. Adhesion problems in the secondary painting phase areas were not as noticeable as in the first painting phase.

² Like heavy rainfall, and floods; to be mentioned here is also wind erosion.

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A comprehensive conservation program for the *Lhakhang Gongma* will have to concentrate mainly on the overall and effective consolidation of the wallpaintings; to be completed by cleaning, filling and integration of cracks and losses, and backfilling of voids. The actual need of action in *Lhakhang Gongma* cannot only focus on the preserving itself but has to address how to preserve and treat both painting phases. In this case, aesthetical factors have to be considered: If to preserve the secondary paintings is not just to be answered by the principal, general conservative need, but the multi-fold values that are related to the over-paintings and their importance to nowadays monastery community and society.

If it comes to the general restoration of the Upper Temple, again, any support of conservators for appropriate accompanying stabilisation of the interior decoration will be required.

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III

CONSERVATION AND PRESERVATION STRATEGY

Approaches to conservation: Specific conservation concepts for the two interiors assessed

As it should be illustrated with the wallpaintings assessment results (s. chapter I and II) the *Dukhang* and the *Lhakhang Gongma* each pose a very specific problem for conservation and preservation.

To summarise: The original murals in the *Dukhang* are preserved in a fragmentary state; the unpainted (areas that do not show original paintings) wall surfaces make a noticeable part of the *Dukhang* interiors overall impression which forms a main problem in the conservation and presentation of the remaining painting fragments.

In contrast, the *Lhakhang Gongma* shows an almost complete, not only original painted but re-painted decoration. Here, the secondary painting phases differ noticeably from the original decoration: In artistic style and colour scheme, but not considerably in iconography. How to deal with this problem forms – beyond the principal consolidation and stabilisation of the wallpaintings themselves – an urgent question for conservation.

1

The *Dukhang* conservation concept:

Roughly estimated, only one third of the murals of the three visible *Dukhang* walls are still existent. Main urge in conservation means to preserve the fragmentary wallpaintings and to make sure that they are presented with their unique spiritual, artistic, and material values – although and because – extensive parts of the walls already lack their painted decoration. A further issue poses the conservation and presentation of the up to now covered murals of the west wall.

It is more than necessary to establish an aesthetical approach how to treat the unpainted wall surfaces. As these areas – that already got re-plastered and repaired and make more than a half of the wall surfaces – will have to serve as a suitable and an aesthetically adequate background for the presentation of the conserved mural fragments.

A re-plastering of the unpainted surfaces could follow the material technology and textural impression of the original fine plaster surfaces which show a fine, smoothened texture in a greyish colour. The large-format re-plastering of the areas mentioned might feature a specific finishing treatment to homogenise the overall painted and unpainted surface appearance.

Through this concept for the *Dukhang*, long-term preservation and an adequate aesthetic integration of the wallpaintings should be guaranteed.

2

The *Lhakhang Gongma* conservation concept:

Here, all the walls are almost completely coated with paintings and one can clearly distinguish between a first and a later decoration phase. The first, original phase could be differentiated further on some areas due to characteristic artistic techniques. It seems very likely that more than one artist decorated the temple interiors.³ The purpose and need of the later, partial over-painted decoration could be traced back to former damage situations. Obviously, secondary paintings were applied to-

³ This becomes evident when comparing the frieze and the upper parts of the walls, as well as when taking a closer look at the main figures and decorative elements as the upper wall decoration.

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gether with repair interventions that had to tackle severe cracks within the masonry and major losses and washouts due to seepage.

The general problem in conserving the murals of the Upper Temple means – besides necessary cleaning and consolidating measures – how to deal with these two very different painting phases: If to preserve the historical structure with both phases or to reveal a possible original painting decoration below its later over-painting.

In principle, conservation ethics consider the artwork with its historical context; the artwork is seen as a part and product of history that can feature many layers and phases in manufacturing. Therefore a complete restoration by means that go back to a proposed “original state” is – ethically – *a priori* not suggested. Discussing the various values of an artwork and the need of its preservation for the related societies should form the base for any decision-making process.

In the *Lhakhang Gongma* conservators were from the very beginning confronted with the general wish to enable and show the original phase if possible and to aesthetically unify the present impression of the interior.

Between the two very opposite approaches, to remove or not remove later over-paintings, a compromise and kind of “way in the middle” might be found that serves both opinions and reflects the specific situation of the site. In this case, the concept finding cannot be only upon the conservators, but the architects and the Buddhist community that should be actively involved in the decision-making process as well.

From the conservator's point of view two very practical/material factors speak against a complete removal of the secondary paint layers in the *Lhakhang Gongma*, besides the ethical considerations already mentioned: Firstly, the original paint layer is assumed not to be preserved throughout the quite extensive over-painted areas. Secondly, materials of both painting phases are water-based; the removal of the upper layer would cause a considerable risk to (if present) under-laying original layer surfaces.

The concept for the Upper Temple wallpaintings conservation first of all means to find and establish a common decision for a suitable concept. For this, the removal, the non-removal, and a conservation compromise will have to be shown on-site and put under discussion. Based on this a further, appropriate, practicable and for all people being involved satisfactory concept can be outlined and become realised.

Implementation of conservation measures: conservation program

Following conservation measures are required in both temples (based on the work experience in Nako):

- Fillings

Filling of cracks and losses within the paintings areas have to be undertaken on all the walls. Filling materials based on earthen materials are suggested.

- Backfilling

Backfilling of voids within the supportive masonry structure will form one of the main tasks in the conservation program due to extent of voids assessed. Backfilling materials should be *d'accord* with the methodology established for the fillings: Considering the specific requirements of the differing supportive masonry components.

- Consolidation

The consolidation of paint layers asks for an applicable treatment according to the damage degree and extent. Large-scale measures as well as selective small-scale interventions are required.

- Cleaning

On-site tests proofed that mainly non-water based cleaning methods should be applied on the paintings surfaces.

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- Removing of deposits

Earthen deposits should be removed by mechanical means. As on some areas deposits showed a strong adhesion to painted surfaces, the thinning of deposits might be a reasonable compromise to on the one hand fulfil aesthetic arguments and on the other hand protect and preserve the highly sensitive paint layer surfaces.

- Removing of re-plastering and the application of repair plasters and suitable finishes

These large-scale tasks ask to be integrated within the architectural conservation program.

Need of on-site tests:

With the tests that cover conservation as well as restoration methods, first results should be achieved to be able to plan coming campaigns for SAVE DANGKHAR. All tested methods followed the work experiences gained through the “Nako Project” of the Institute of Conservation from 2004-2010 (s. *Nako Project reports 2004-2010*).

To define and specify appropriate conservation measures for both sites it was necessary to perform different on-site tests. Aim of these tests was to learn more about the present condition of the murals and their adequate treatment so that an applicable program for the single measures and conservation steps could be worked out. The tests could only serve to get a first and general overview about the murals characteristics and performance, more detailed tests should follow in the future and go along with coming on-site campaigns.

In general conservation measures for the treatment of the wallpaintings cover following tasks: Cleaning, consolidation of paint layers, filling and integration of cracks and losses. For all these conservation steps various proofed methods were tested on-site in both temples exemplarily on representative testing areas.

Dukhang:

As the wallpaintings are preserved in a very fragmentary state it was not clear if all wallpaintings go back to the same painting phase. On-site tests showed that all four walls are painted nearly with the same painting materials according to the similar results from solubility tests. Tests with different polar and non-polar solvents as water, ethanol, isopropanol, acetone and xylol confirmed that the binding media used are throughout only soluble in water.

For testing different cleaning methods both wet as well as dry methods were applied. Deposits on the surface as dust, soot and earthen splashes from previous repairs, could be removed most satisfactory by a very careful water based treatment. It is to mention here that this method bears a certain risk if not applied professionally as the wallpaintings are in general water-soluble!

Cleaning with non-water based methods using various types of sponges showed only moderate success.

Thick earthen deposits could be removed through a combination of moistening the deposits and the use of mechanical methods as scalpel. This treatment method needs to be developed further due to the very sensitive surface of the murals and the risk in removing paint layers together with the deposits.

Concerning the consolidation of flaking and chalking areas as well as losses within the paint layers different methods have been tested. The methods and materials chosen and successfully applied for the wallpaintings conservation program in Nako could not similarly claim to be the adequate solution for the murals in Dangkhar.

As a first method a large-scale consolidation method was tested on flaking painted surface areas. Therefore a hydroxypropyl-cellulose which was applied by brush using a sheet of Japanese tissue as a protective layer was used [Klucel E 2% in ethanol:isopropanol (1:1)]. This treatment had to be re-done several times to obtain any consolidation effect. As the result was not sufficient one has to think of increasing the amount of consolidation medium or to apply the medium differently. Due to this rather poor result a further consolidation method was tested. The consolidation medium was applied onto the wallpaintings by infiltration. With this method flakes with detached edges could be successfully consolidated.

The issue of an appropriate consolidation method with respect to the adequate consolidation medium and application process needs to be further discussed and tested in the coming campaign.

As another important on-site test the filling of big losses was carried out exemplarily. Also for this conservation treatment experiences from the “Nako Project” could be used. Filling materials based on local earthen materials were tested and indicated a good plasticity performance that is practicable to work with. In general, filling with lo-

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cally available earthen materials integrates and fits very well to the original plaster structure concerning colour and texture. This method and material could be applied for the fillings of cracks and losses; it might be necessary to adjust the treatment process in areas with specific filling problems.

To summarise the on-site tests in the *Dukhang*: The results could indicate treatment processes that worked successfully. But especially cleaning and consolidation methods must be discussed further and improved when being implemented into a comprehensive and effective conservation program.

Lhakhang Gongma:

To gain more knowledge about the materiality of the two evident painting phases and practicable approaches how to deal with them solubility tests were carried out. Tests on the murals in the Lhakhang Gongma showed similar results as in the *Dukhang*, here both painting phases were soluble in water, but not in ethanol, isopropanol, acetone and xylol. The glossy varnish that partly covers the secondary paintings is soluble in ethanol and acetone.

As the murals are highly water-soluble water-based cleaning methods are hardly possible to apply. Due to this fact only dry cleaning methods were tested. Again different sponge types were tested but like in the *Dukhang* the results showed moderate to no effects.

Earthen deposits could be removed by mechanical methods using various brushes. It should be mentioned that the murals are very sensitive, so that one has to work extremely carefully not to harm the surface and take off single pigments. Regarding this fact the first painting layer seems to be more stable, here a treatment with soft brushes and sponges showed good results.

Concerning consolidation of the painted surface the same methods as in the *Dukhang* were tested – firstly large-scale consolidation method with Japanese tissue and secondly consolidation by infiltration. In both cases hydroxypropyl-cellulose diluted in ethanol was used. For the first method an area with a flaking surface was chosen. The treatment confirmed the result of the *Dukhang*: It was necessary to perform the consolidation procedure several times and the ratio of the medium dissolved had to be raised. This method proofed not to be useful for flaking areas because it showed far too little consolidation effects. A surface colour change due to the consolidation medium applied could not be noticed. Only the pigments got a more brilliant appearance as the colours were more saturated.

The second method using injections for the infiltration of the consolidating medium showed to be more efficient. A repeated infiltration procedure was again necessary, but on the whole, the consolidation effect was more successful than the first method described.

Also in the *Lhakhang Gongma* fillings of losses were tested following the methods applied in Nako. Local earthen materials were filtered through a 3 mm mesh and then suspended into water. This filling material showed enough plasticity for the workability required. Also the natural colour of the local clay seemed suitable for the wall paintings. After drying, the filler had a light greyish colour that fitted perfectly to serve as a “neutral” surface.

To summarise the results of the on-site tests in the *Lhakhang Gongma*: It can be stated that as far as the conservation concept is concerned further tests have to take place. These on-site tests could give a first impression on the murals and indicate in which direction further tests should move. Regarding the treatment for cleaning and consolidation future tests have to clarify the best and most efficient method.

Starting in 2012: Planning the realisation of the wallpaintings conservation program

In general, wallpainting conservation measures are to accompany and follow – not to proceed – architectural stabilisation measures. Therefore the wallpaintings conservation program must be planned in accordance with the general renovation and be part of the subsequent steps to be realised within the architectural working process.

Due to restrictions of the site it is suggested that a small team of four conservation specialists will implement the necessary conservation tasks. Three senior professionals from the Institute of Conservation are foreseen to form the team supported by one or two conservation students.

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2012 – exemplary realisation and presentation of the two suggested conservation concepts:

For the wallpaintings conservation program 2012 will be crucial in finding an appropriate and applicable working schedule for the years to come. 3 senior conservation professionals together with 1-2 students are planned to undertake the next conservation summer campaign in summer 2012. Dates and the exact working schedule need to be fixed in accordance with the architects working program. Material and infrastructure related issues are to be organised accordingly in spring 2012.

Above all, it will be necessary that in 2012 the different conservation problems in the two temples can be addressed exemplarily by practical measures by the team. Conservation treatments according to the two concepts described are to prove the applicability of the approaches outlined. For this, in each temple one representative area is foreseen to be treated as an example, then presented, and put under general discussion before the overall implementation for both interiors can be undertaken.

In the *Dukhang* one representative area will be chosen. Here, the different conservation steps (cleaning, consolidation, filling, and back-filling) will be applied accompanied by further on-site testing and improvement of the conservation methods proofed so far. In completion, several testing areas will be foreseen where different plasters and plaster finishes are applied to be compared and selected. Based on this conservation example for the painted fragments and the integration of unpainted surfaces a program for an overall implementation can get set up.

In the *Lhakhang Gongma* the two very differing approaches regarding the treatment of the secondary paintings will be carried out on a suitable testing area. Besides the preserving and removing of later paint layers another compromise in treatment will be worked out: it seems possible that some of the over-paintings may be reduced and others have to remain. Here, the conservators team needs to find out a practicable and aesthetically satisfactory way. These three exemplary conservation approaches should serve as a visual and profound base for a final and common decision making on how to proceed. The required conservation measures to be applied on all the walls will also in the *Lhakhang Gongma* have to be developed further. At the end of the 2012 campaign a suitable conservation concept for the Upper Temple should be confirmed and agreed by all decision makers being involved so that its realisation can get planned and started.

Based on the 2012 working results a long-term implementation schedule for the wallpaintings conservation in the *Dukhang* and the *Lhakhang Gongma* can be established starting with summer campaign 2013.

2013

In 2013 the subsequent implementation of the established schedule can become realised. The concepts for both interiors will put into practice step by step: Through this allowing necessary adjustments to the actual on-site situations and being able to react to changing requirements if needed.

Recommendations: Supportive conservation and preservation measures

One has to bear in mind that paintings conservation treatments might not just be needed for the most prominent wallpainting decorations in the *Dukhang* and *Lhakhang Gongma*.

Accompanying the overall architectural interventions, protective conservation treatments might also be needed for other painted interiors of the monastery complex like the Dalai Lama's room. Therefore it is recommended that overall supportive conservation and preservation measures are to be included as a supportive part within the general architectural working progress. The supportive conservation program will have to be flexible and to be adjusted to the actual architectural working steps.

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IV

PHOTODOCUMENTATION, GRAPHIC RECORDING, ANALYSES REPORT

An overall photographic documentation of the wallpaintings structures serves to illustrate the assessment results so far; the graphic recording visualises the assessment results also in a quantitative way.

Both the documentation means not just give evidence to the field work undertaken but form an important base for the coming conservation work.

The scientific analyses report on the clarification of painting technology completes the documentation of the assessment undertaken.

A Dukhang



Fig.1. Sculpture before treatment



Fig.2. Sculpture after treatment



Fig.3. West wall detail



Fig.4. Green Tara detail, first and second paint layer



Fig.5. Wall behind the wooden construction with usually covered wallpaintings



Fig.6. Wall behind the wooden construction with intact although decayed wall paintings



Fig.7. Dustlayers



Fig.8. Flaking areas and losses of paint layers



Fig.9. Losses of paint layers, thinned painted surface and deposits



Fig.10. Detail of losses and flaking areas



Fig.11. Crack



Fig.12. Repair-filling, deposits in form of channels



Fig.13. Unpainted surface



Fig.14. Detail, cleaning with water



Fig.15. Detail before cleaning with sponges



Fig.16. Detail after cleaning with almost no visible effect

B Dalai Lama's Room



Fig.1. Deep cracks and losses of paint layer and plastering



Fig.2. Voids, cracks and losses of paint layer and plastering

C Lhakhang Gongma



Fig.1. Frieze detail, first painting phase



Fig.2. Second painting with elements of the first painting phase still visible (e.g. clothes, hands)



Fig.3. The two painting phases with glossy varnish

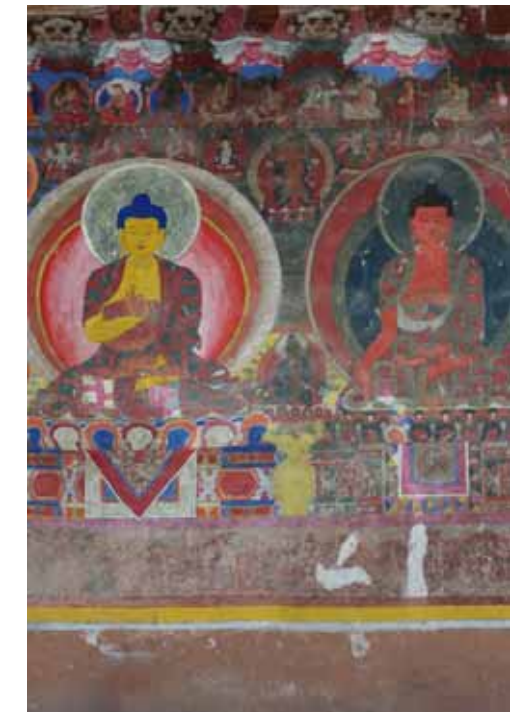


Fig.4. The two painting phases without glossy varnish



Fig.5. Dustlayer



Fig.7. Losses of the paint layer with overpainting



Fig.6. Flaking and losses of the paint and ground layer



Fig.8. Deep crack and losses



Fig.9. Surface deposits, drips out of a crack



Fig.10. Earthern deposits onthe murals



Fig.11. Voids, cracks and losses



Fig.12. Test area for varnish removal



Fig.13. Test area for consolidation of flaking










Fig.14. Test area for filling of losses

Photos © University of Applied Arts Vienna, Institute of Conservation

D Mapping the Dukhang interior walls










Map.1. The Dukhang North wall

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.2. The Dukhang North wall with the extent of undecorated plaster, repair and recoated surfaces indicated

Mapping glossary:








	Unpainted wall surfaces in the Dukhang
	Secondary painting phase in the Lhakhang Gongma
	Thinned painted surfaces
	Washouts, waterdrops, water drips
	Flaking painted surfaces
	Cracks within masonry and plasters
	Voids within masonry and/or plaster layers



Map.3. The Dukhang North wall showing voids, cracks, flaking and thinned painted surfaces










Map.4. The Dukhang East wall

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.5. The Dukhang East wall with the extent of undecorated plaster, repair and repainted surfaces indicated

Mapping glossary:








	Unpainted wall surfaces in the Dukhang
	Secondary painting phase in the Lhakhang Gongma
	Thinned painted surfaces
	Washouts, waterdrops, water drips
	Flaking painted surfaces
	Cracks within masonry and plasters
	Voids within masonry and/or plaster layers



Map.6. The Dukhang East wall showing voids, cracks, washouts and drips, flaking and thinned painted surfaces




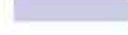





Map.7. The Dukhang South wall

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.8. The Dukhang South wall with the extent of undecorated plaster, repair and repainted surfaces indicated

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers










Map.9. The Dukhang South wall showing voids, cracks, wahouts and drips, flaking and thinned painted surfaces

E Mapping the Lhakhang Gongma interior walls




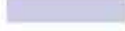





Map.10. The Lhakhang Gongma Northeast Wall

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers










Map.11. The Lhakhang Gongma Northeast wall with secondary, over-painted areas defined

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers










Map.12. The Lhakhang Gongma Northeast wall showing voids, cracks, washouts and drips, flaking and thinned painted surfaces

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers




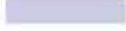





Map.13. The Lhakhang Gongma Southeast wall

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.14. The Lhakhang Gongma Southeast wall with secondary, over-painted areas defined








- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.15. The Lhakhang Gongma Southeast wall showing voids, cracks, washouts and drips, a water horizon, flaking and thinned painted surfaces




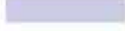





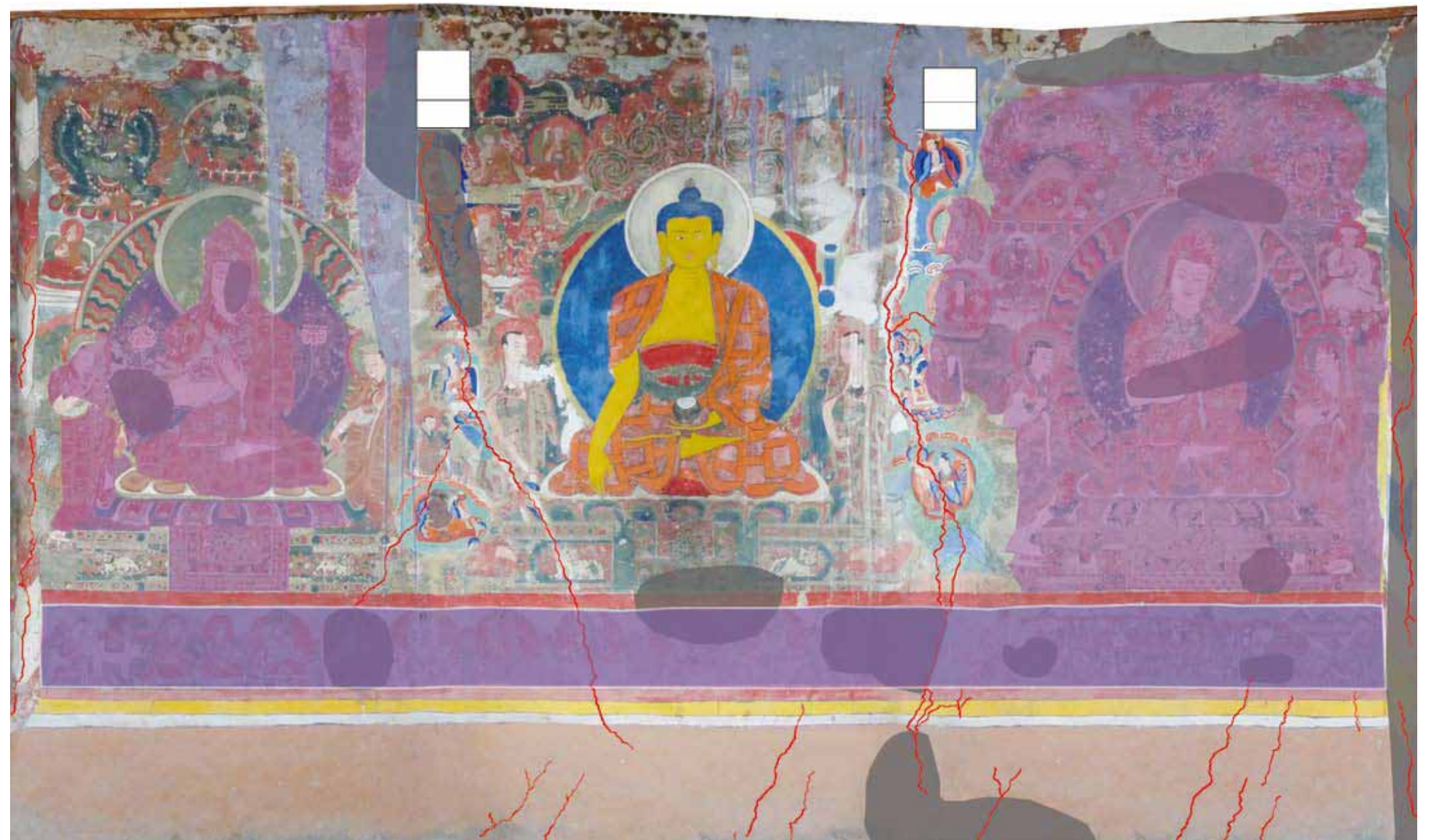
Map.16. The Lhakhang Gongma Southwest wall

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.17. The Lhakhang Gongma Southwest wall with secondary, over-painted areas defined








- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers

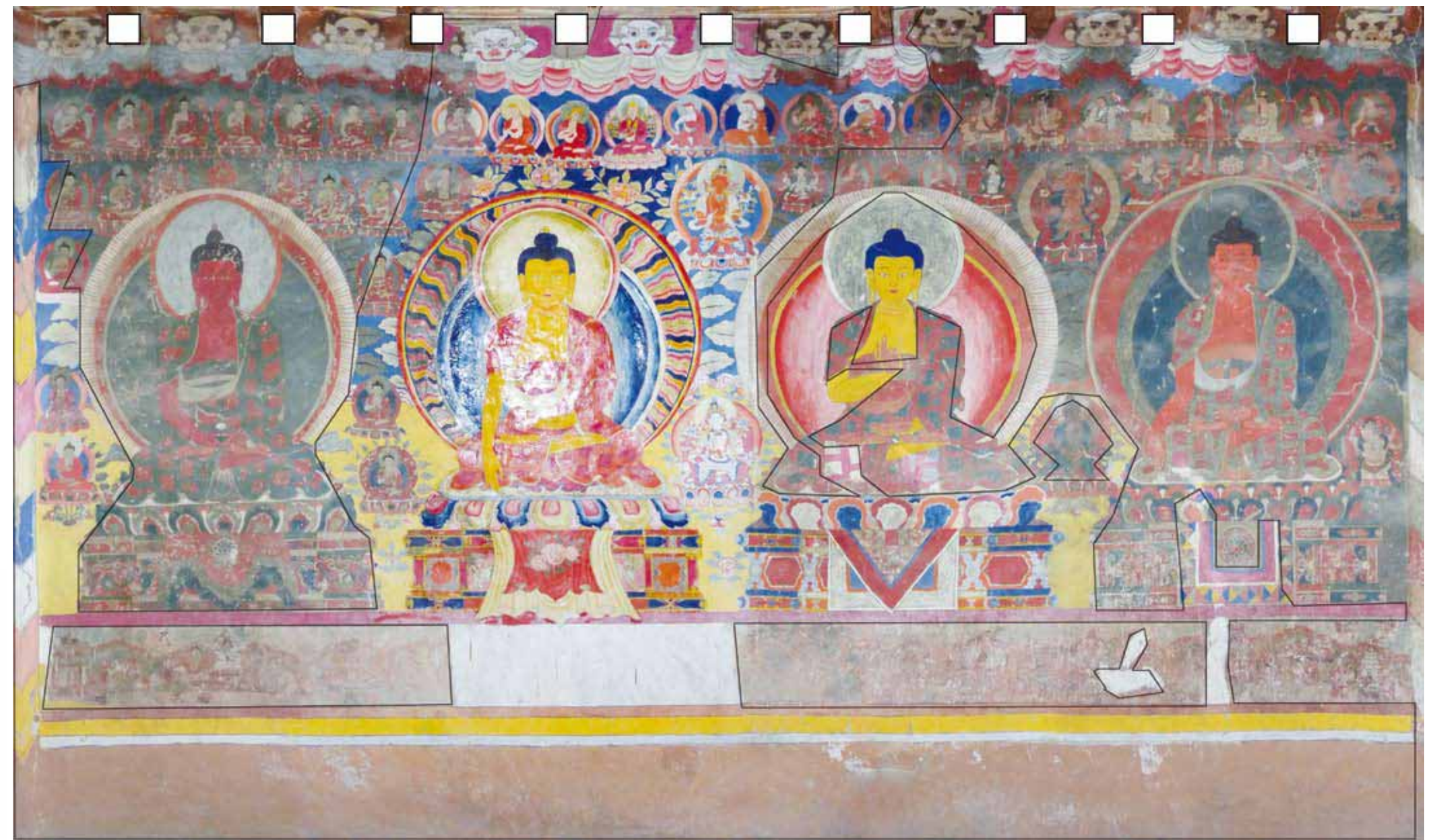


Map.18. The Lhakhang Gongma Southwest wall showing voids, cracks, washouts and drips, flaking and thinned painted surfaces




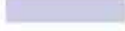





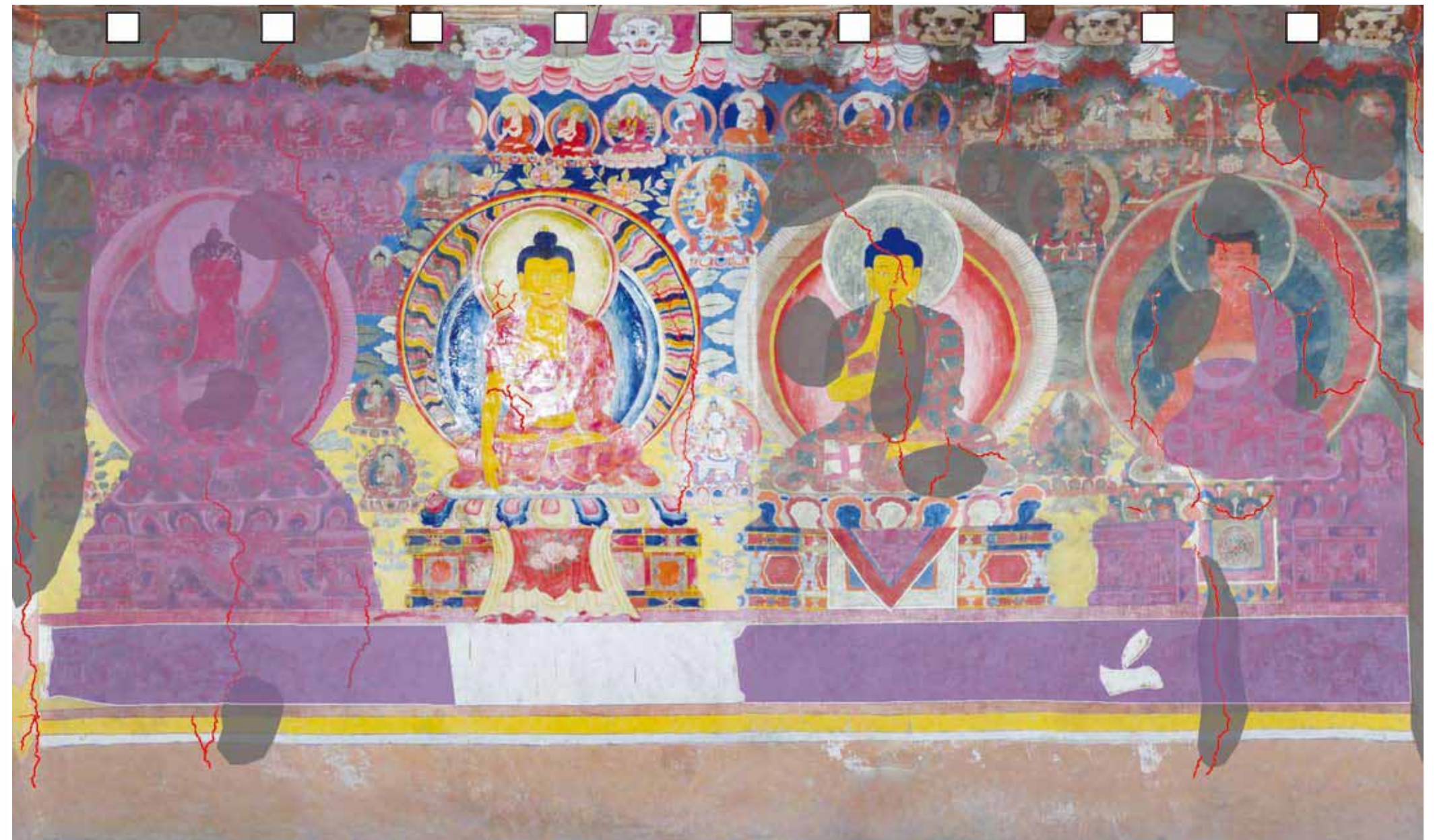
Map.19. The Lhakhang Gongma Northwest wall

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.20. The Lhakhang Gongma Northwest wall with secondary, over-painted areas defined

- Mapping glossary:
-  Unpainted wall surfaces in the Dukhang
 -  Secondary painting phase in the Lhakhang Gongma
 -  Thinned painted surfaces
 -  Washouts, waterdrops, water drips
 -  Flaking painted surfaces
 -  Cracks within masonry and plasters
 -  Voids within masonry and/or plaster layers



Map.21. The Lhakhang Gongma Northwest wall showing voids, cracks, washouts and drips, flaking and thinned painted surfaces

Dangkar monastery, district of Lahaul and Spiti, Himachal Pradesh, India

A technical study of wall paintings – preliminary report

Place: Dangkar monastery, Himachal Pradesh, India

Object: Wall paintings

Purpose of the investigation:

- Characterisation of layers
- Identification of binding media
- Identification of pigments
- Determination of the painting technique

Samples taken by: Dr. Mag. Maria Gruber, Mag. Kathrin Schmidt

Date of sampling: July 2011

Number of samples: 6

Samples description:

604 (07 U)	Upper Temple, South-east wall “Fries” in sky underneath the 2 nd Buddha from the left; original (?)
605 (02 U)	Upper Temple, North-west wall 2 nd Buddha from the left, red underneath his left leg; overpainting (?)
606 (04 U)	Upper Temple, South-west wall 1 st figure in red cloth, place above the left knee; original (?)
607 (01 DL)	Dalailama’s room, wall with the door Left side of the wall painting, over the door. Modern painting (?)
608 (01 D)	Dukhang, West wall Dark background on the left side of the wall. Probably original painting (?), no older phases are visible.
609 (04 D)	Dukhang, North wall “Green Tara” on the left side of the wall. Probably overpainting with the original painting (?) underneath.

Analytical methods:

- Optical microscopy in reflected light (OM)
- Scanning electron microscopy with energy-dispersive X-ray analysis (SEM-EDX)
- Spot tests (ST)
- Tests of solubility
- Staining tests (StT)

Experimental:

Samples preparation

Cross-sections for studying layer build-up were prepared by mounting of samples in acrylic resin (Spofacryl, Dental a.s.) followed by dry grinding and polishing.

Stratigraphy of layers and analysis of inorganic components

Light microscopy of cross-sections was carried out in normal reflected light and UV-fluorescence-microscopy using Nikon Eclipse ME 600 microscope fitted with digital camera Nikon Coolpix 990; 100W halogen lamp, 100W high pressure mercury lamp, UV filter 330-380 nm.

For scanning electron microscopy of cross-sections a Philips XL-30 ESEM¹ under high vacuum at an acceleration voltage 20kV, fitted with the X-ray device was used.

Legend to the SEM-EDX measurements: A – area analysis, S – spot analysis, main elements are bold, trace or uncertain elements are in parentheses.

Identification of organic binding media

Spot tests (microchemical tests)² to indicate the types of binding media (oils, proteins and plant gums) were performed directly on selected scrapings; layers were separated from each other as far as possible.

Testing for drying oils (test of presence of glycerol), for proteins (detection of pyrrole-derivatives), for plant gums (detection of pentoses with 5-methyl-resorcin) and for starch (detection of starch using the iodine/potassium iodide solution in water – Lugol’s solution) were undertaken.

Results of the spot tests were complemented with the results of the staining tests (histochemical analyses)^{3,4} performed on the cross-sections. Following staining agents were used:

Amido black AB2 (0,1%-solution in a mixture of water and glycerol) and Ponceau S (saturated solution in 1%-acetic acid) – staining for proteins detection

Sudan Black B (saturated solution in 60% isopropanol) – staining for oils detection

Results:

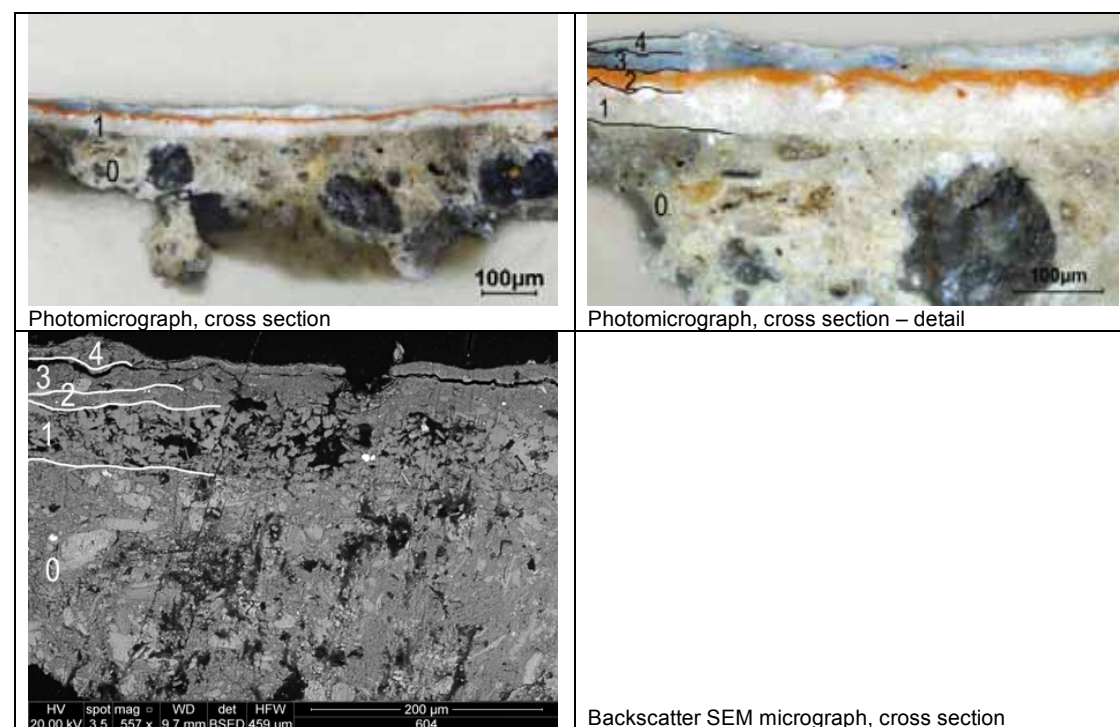
Samples description, stratigraphy of paint layers, microphotographs of cross-sections and the results of all analyses performed are summarised in the following pages.

¹ Measurements undertaken by DI Karol Bayer, Institute for Art and Technology, University of Applied Arts Vienna.

^{2,4} Schramm, H.P., Hering, B.: Historische Malmaterialien und ihre Identifizierung, Stuttgart 1995.

³ Martin, E.: Some Improvements in Techniques of Analysis of Paint Media, Studies in Conservation, 22 (1977), p.63-67.

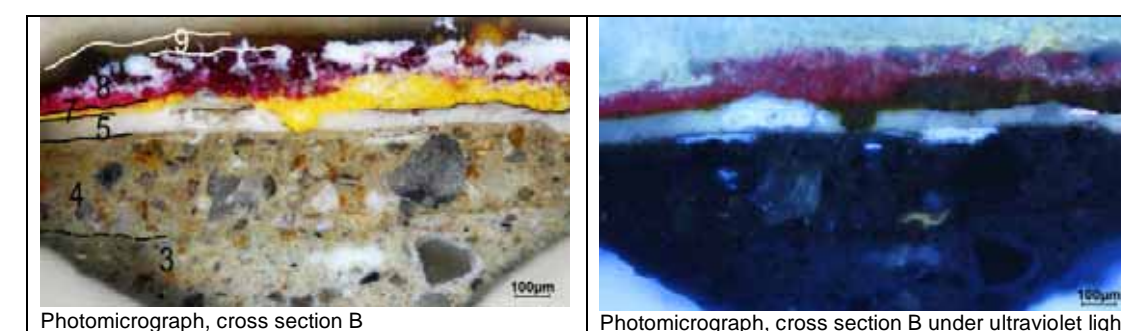
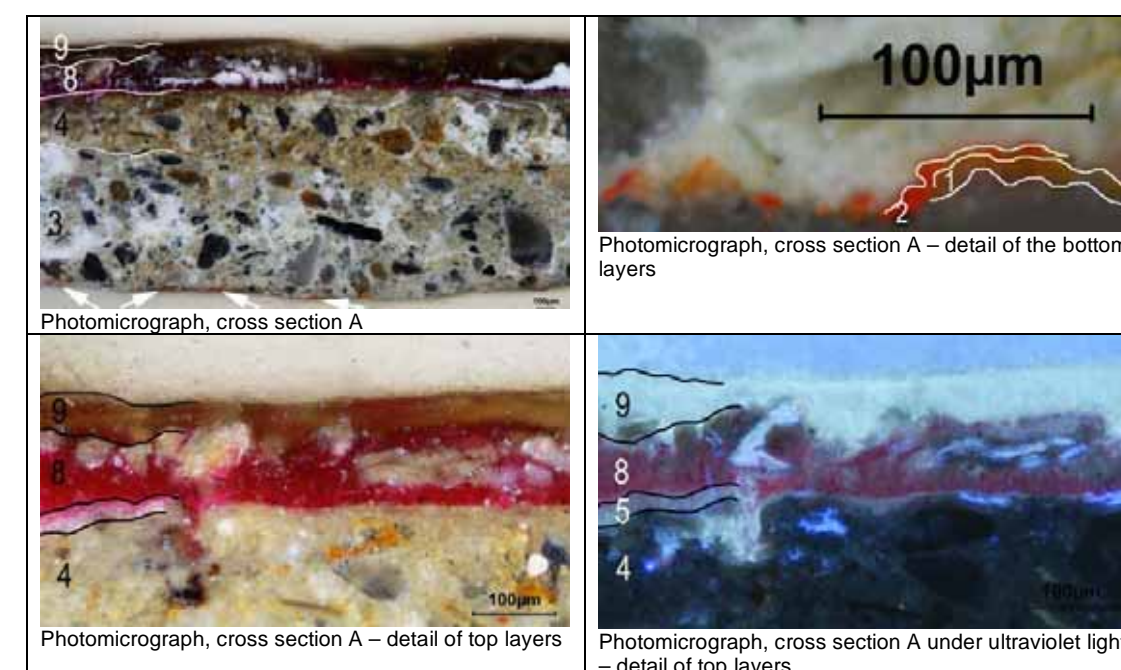
Sample Nr	604 (07 U)
Temple / Location	Danghkar monastery, Upper Temple, Southeast wall
Location / Description	"Fries" in sky underneath the 2 nd Buddha from the left; original (?)
Sampled by / Date	Kathrin Schmidt, 18 July 2011
Methods of analyses	OM, SEM-EDS, ST, StT
On-site sample description	Plaster →ground→orange paint layer (?)→white paint layer The surface of the painting is matt; "fries" paintings are very detailed and look like very sophisticated paint technique.
Purpose of sample	Characterisation of layers. Identification of binding media. Identification of pigments. Determination of the painting technique.

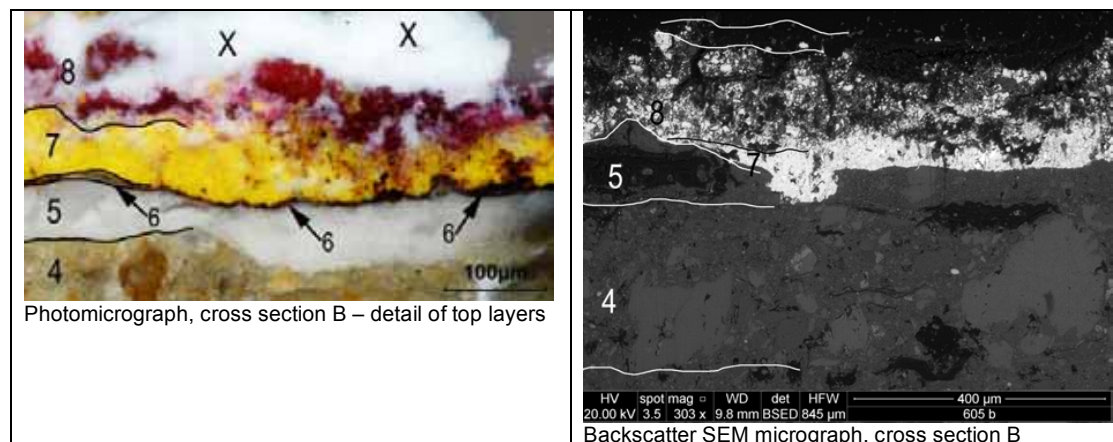


Layer Nr	Description and composition of layer	SEM-EDS-elemental analysis
4-	White layer containing gypsum and silicates, binding media is protein, highly probably animal glue.	A: S,Si,Ca,(Al,Mg,K)
3-	Light blue layer – on the left side of the cross section; contains gypsum and small amount of very fine grained blue pigment – probably indigo (pigment was not identified); binding media is protein, highly probably animal glue.	A: Ca,S ,(Si,Al,Mg,K)
2-	Orange layer – homogeneous, contains very fine ochre and gypsum; binding media is protein, highly probably animal glue.	A: Si,Al,S,Ca,Fe ,(Mg,K)
1-	White ground layer based on gypsum composed of particles of different shape and size. Gypsum contains some impurities in the form of silicates. Binding media is protein, highly probably animal glue, mixed with starch.	A: Ca,S ,Si,Al,(Mg,K)
0-	Earthen plaster layer of light grey-brown colour, medium coarse, grains up to 150 µm; contains various rock grains and grains of calcium carbonate. The surface of the plaster was probably smoothened.	A: Si,Al,Ca,Mg,K ,(Fe)

The surface of the fragment was first observed under the stereo microscope. On the surface as well as on the edges of the fragment there is clearly visible thin transparent organic layer indicating previous conservation treatment.

Sample Nr	605 (02 U)
Temple / Location	Danghkar monastery, Upper Temple, North-west wall
Location / Description	2 nd Buddha from the left, red underneath his left leg; overpainting (?)
Sampled by / Date	Kathrin Schmidt, 18 July 2011
Methods of analyses	OM, SEM-EDS, ST, StT
On-site sample description	Filling material→ground (?)→red paint layer (?)→glossy surface The surface of the painting is very glossy.
Purpose of sample	Characterisation of layers. Identification of binding media. Identification of pigments. Identification of the glossy varnish. Confirmation of the presence of secondary layers.

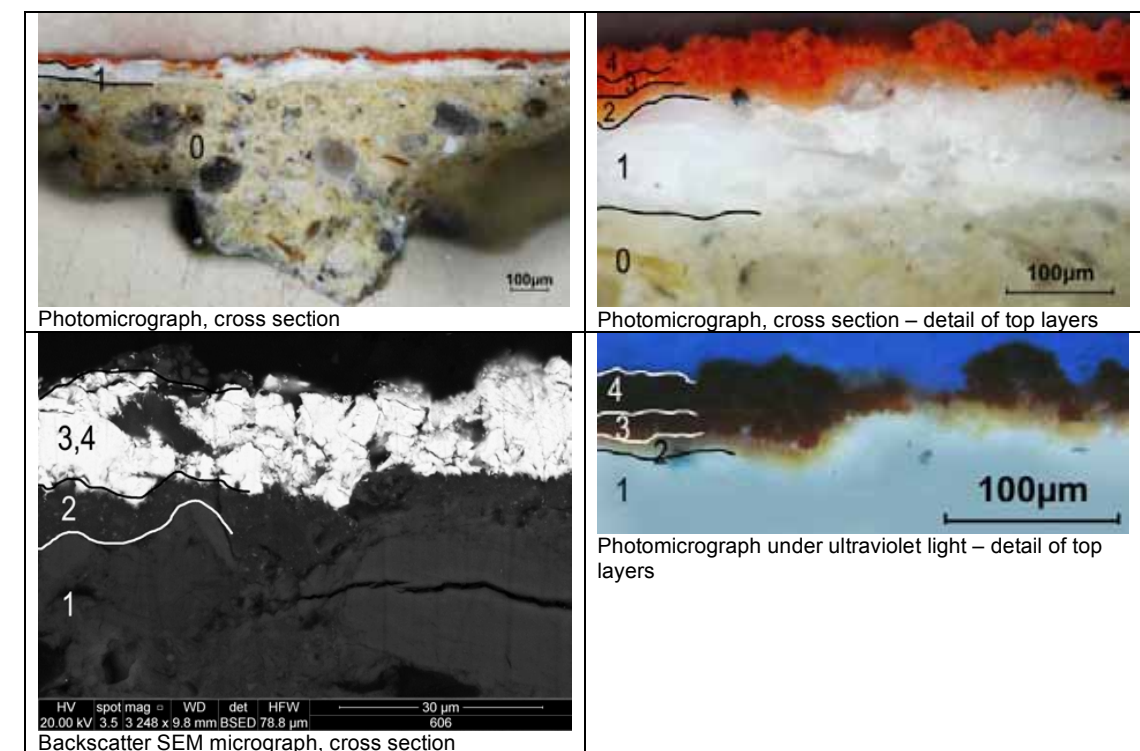




Layer Nr	Description and composition of layer	SEM-EDS-elemental analysis
9-	Yellowish varnish, thick, based on protein, highly probably animal glue.	
8-	Purple-red layer containing red dye (synthetic? natural?) and baryte and gypsum as fillers; binding media is protein, highly probably animal glue. (White areas marked with "X" are holes filled with dust from grinding).	A: Ba,S,Ca
7-	Yellow layer*, containing lead white, chrome yellow and baryte; binding media is protein, highly probably animal glue. The layer is present only in the cross section B.	A: Pb,Ba,S,Cr
6-	Dark red-black layer, very thin – present only in the cross section B.	
5-	White ground layer, very thin, based on gypsum. Binding media is protein, highly probably animal glue.	A: Ca,S,Si,Al,(Mg,K)
4-	Earthen plaster layer of grey-brown colour, medium coarse, grains up to 150 µm; contains various rock grains, grains of calcium carbonate and addition of gypsum.	A: Si,Al,Ca,S,(K,Mg),(Ti,Fe)
3-	Earthen plaster layer of grey-brown colour, medium coarse, grains up to 150 µm; contains various rock grains and grains of calcium carbonate.	A: Si,Al,Ca(K,Mg),(Ti,Fe)
2-	Red layer containing vermilion (probably dry processed) – present only in the cross section A.	A: Hg,S
1-	Orange layer – homogeneous, contains very fine ochre and gypsum – present only in the cross section A.	A: Si,Al,K,Ca,Mg,(Fe)

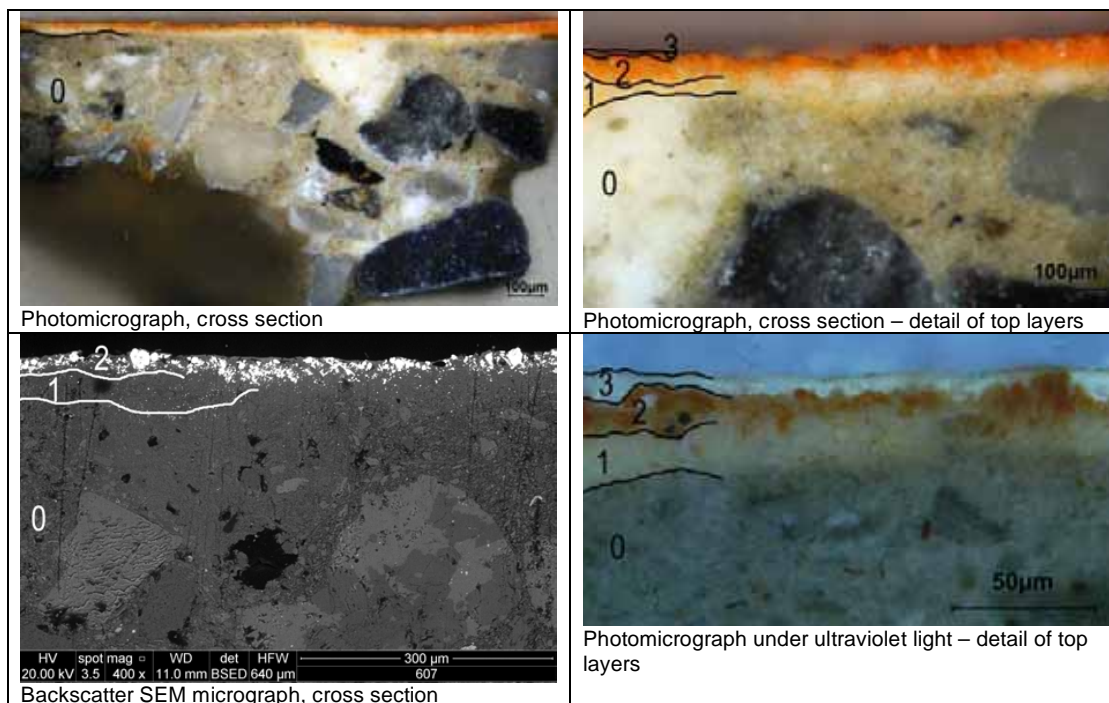
* Yellow and purple-red layers are secondary layers containing pigments chrome yellow and baryte, used from the nineteenth century.

Sample Nr	606 (04 U)
Temple / Location	Dangkhar monastery, Upper Temple, Southwest wall
Location / Description	1 st figure in red cloth, place above the left knee; original (?)
Sampled by / Date	Kathrin Schmidt, 18 July 2011
Methods of analyses	OM, SEM-EDS, ST, StT
On-site sample description	Plaster →ground→red paint layer The surface of the painting is matt.
Purpose of sample	Characterisation of layers. Identification of binding media. Identification of pigments. Determination of the painting technique.



Layer Nr	Description and composition of layer	SEM-EDS-elemental analysis
4-	Red layer containing vermilion (probably dry processed), grains size 5-10 µm; binding media is protein, highly probably animal glue.	A: Hg,S
3-	Red layer containing vermilion (probably dry processed), grains size 5-10 µm; binding media is protein, highly probably animal glue.	A: Hg,S
2-	Orange layer – homogeneous, contains very fine ochre and gypsum; binding media is protein, highly probably animal glue.	A: Si,Al,S,Ca,K,Fe,Mg,(Ti)
1-	White ground layer, very compact, based on gypsum composed of particles of different shape and size. Gypsum contains some impurities in the form of silicates. Binding media is protein, highly probably animal glue, mixed with starch.	A: Ca,S,Si,(Al,Mg,K)
0-	Earthen plaster layer of light brown colour, medium coarse, grains up to 100 µm; contains various rock grains, grains of calcium carbonate and addition of gypsum. The surface of the plaster was probably smoothed.	A: Si,Ca,Al,S,Mg,K,Fe, (Ti,Na)

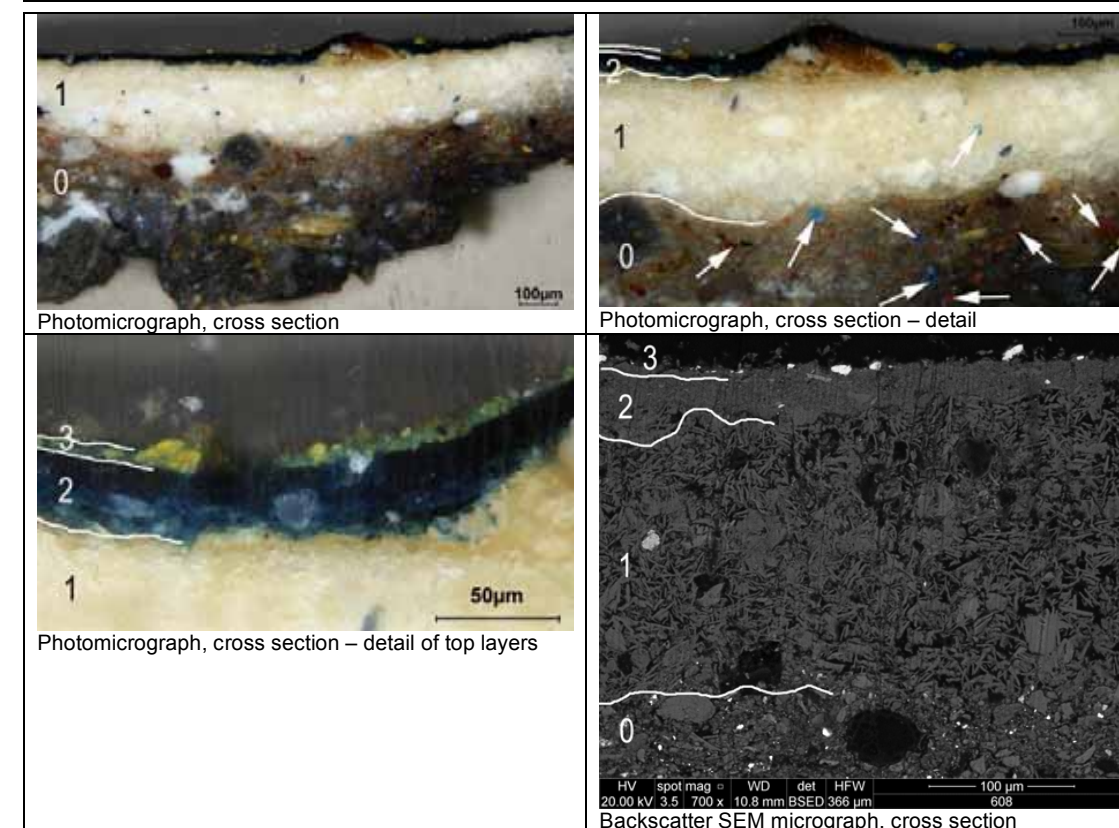
Sample Nr	607 (01 DL)
Temple / Location	Dangkar monastery, Dalailama's room, wall with the door
Location / Description	Left side of the wall painting, over the door. Modern painting (?)
Sampled by / Date	Maria Gruber, Kathrin Schmidt, 21 July 2011
Methods of analyses	OM, SEM-EDS, ST, StT
On-site sample description	Plaster → ground → orange paint layer The surface of the painting is glossy.
Purpose of sample	Characterisation of layers. Identification of binding media. Identification of pigments. Determination of the painting technique.



Layer Nr	Description and composition of layer	SEM-EDS-elemental analysis
3-	Yellowish varnish, thick; white yellowish fluorescence indicates the presence of glue. Presence of proteins was confirmed by spot tests as well as by the staining tests. Binder of the varnish is based on protein, highly probably animal glue.	
2-	Orange layer – homogeneous, contains red lead and gypsum; binding media is protein, highly probably animal glue.	A: Pb ,Ca,S
1-	White ground layer, very compact, based on gypsum that contains some impurities in the form of silicates. Binding media is protein, highly probably animal glue.	A: Ca,S ,Si,(Al)
0-	Earthen plaster layer of light brown colour, coarse, grains up to 1 mm; contains various rock grains, grains of calcium carbonate and addition of gypsum. The surface of the plaster was probably smoothened.	A: Si ,Ca,Al,S,Mg,K,(Fe)

The dating of the painting based on the pigments composition is not possible.

Sample Nr	608 (01 D)
Temple / Location	Dangkar monastery, Dukhang, West wall
Location / Description	Dark background on the left side of the wall. Probably original painting (?), no older phases are visible.
Sampled by / Date	Kathrin Schmidt, 17 July 2011
Methods of analyses	OM, SEM-EDS, StT
On-site sample description	Plaster → ground → dark blue paint layer The surface of the painting is matt.
Purpose of sample	Characterisation of layers. Identification of binding media. Identification of pigments. Determination of the painting technique.



Layer	Description and composition of layer	SEM-EDS-elemental analysis
3-	Yellow-greenish layer containing indigo and orpiment. Binding media seems not to be based on protein (negative staining for proteins); the nature of the binder is under the investigation.	A: As,S
2-	Blue layer applied in two layers, contains indigo and gypsum. Binding media seems not to be based on protein (negative staining for proteins); the nature of the binder is under the investigation.	A: Ca,S
1-	White ground layer containing gypsum of higher porosity, particles are mostly elongated. The gypsum contains only some impurities in the form of silicates. Binding media is protein, highly probably animal glue, mixed with starch.	A: Ca,S ,(Si,Al,Mg)
0-	Earthen plaster layer of darker brown colour, medium coarse, grains up to 100 µm; contains various rock grains and grains of calcium carbonate. The plaster contains also pigment grains (marked with arrows) – grains of vermillion, azurite and orpiment that very probably originate from the older painting. By the application of the secondary plaster the surface of the original water-soluble paint-layers (probably bound with animal glue) was wetted and partly destroyed and the pigment particles were partially transported to the newly applied plaster.	A: Si ,Ca,Al, Mg,K,(Fe)

The painting is very probably not the original one.

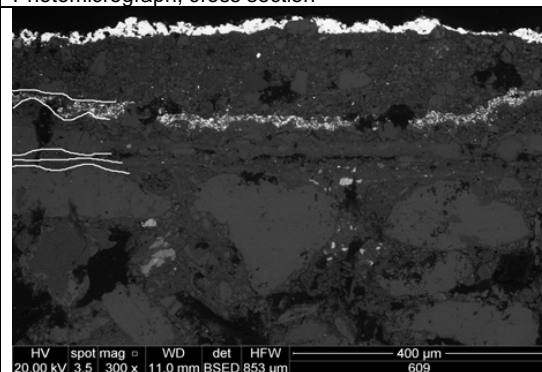
Sample Nr	609 (04 D)
Temple / Location	Danghkar monastery, Dukhang, North wall
Location / Description	“Green Tara” on the left side of the wall. Probably overpainting with the original painting (?) underneath.
Sampled by / Date	Kathrin Schmidt, 18 July 2011
Methods of analyses	OM, SEM-EDS, ST, StT
On-site sample description	Plaster → ground → underlayer (?) → red paint layer The surface of the painting is matt.
Purpose of sample	The presence of overpainting? Characterisation of layers. Identification of binding media. Identification of pigments. Determination of the painting technique.



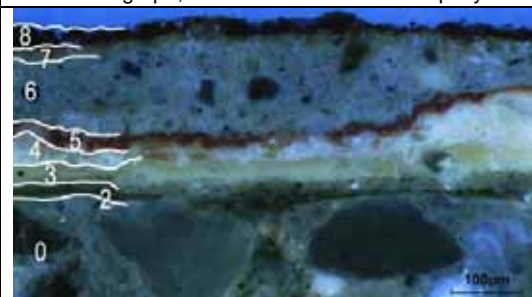
Photomicrograph, cross section



Photomicrograph, cross section – detail of top layers



Backscatter SEM micrograph, cross section



Photomicrograph under ultraviolet light – detail of top layers

Layer Nr	Description and composition of layer	SEM-EDS-elemental analysis
8-	Red layer containing vermilion; binding media is protein, highly probably animal glue.	A: Hg,S
7-	Orange layer – homogeneous, contains very fine ochre and gypsum; binding media is protein, highly probably animal glue.	A: Si, Al,Ca,Mg,K,Fe
6-	Earthen plaster layer of light brown colour, fine grained, contains various rock grains, grains of calcium carbonate and addition of gypsum.	A: Si,Ca,Al,S,Mg,K,(Fe)
5-	Red layer containing vermilion and gypsum. Binding media is protein, highly probably animal glue.	A: S,Hg,Ca
4-	White ground based on gypsum. Binding media is protein, highly probably animal glue, probably mixed with small amount of starch.	A: Ca,S
3-	Thin secondary earthen plaster of light brown colour, fine grained.	
2-	Thin green layer based on indigo and orpiment; binding media is protein, highly probably animal glue.	A: As,S
1-	Thin white ground layer based on gypsum (not visible in the microphoto). Binding media is protein, highly probably animal glue, mixed with starch.	A: Ca,S,Si,(Al)
0-	Earthen plaster layer of grey colour, coarse, grains up to 1.5 mm; contains various rock grains, grains of calcium carbonate and small amount of gypsum.	A: Si,Ca,Al,(Mg,K,S),((Fe))

		Protein	Starch
604 G o		+	+
604 PL o		+	-
	605 G s	+	-
	605 PL s	+	-
606 G o		+	+
606 PL o		+	-
	607 G s?	+	-
	607 PL s?	+	-
	608 G s	+	+
	608 PL s	- (?)	-
609 G o		+	+
609 PL o		+	-
	609 G s	+	-
	609 PL s	+	-