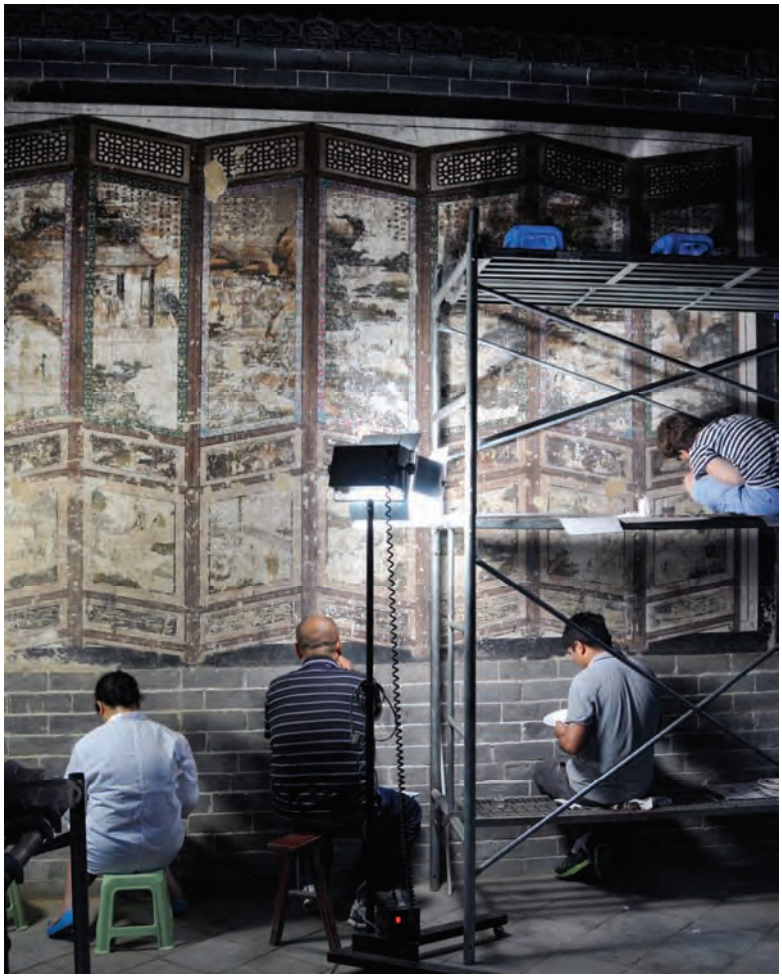
The Murals of the beiwusheng huiguan in Ziyang

Final report

Part 2: Condition, Conservation and Restoration



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Research Institute for Conservation of
Cultural Heritage of Shaanxi Province
陕西省文物保护研究院

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ABSTRACT

Condition, Conservation and Restoration of *Pingfeng Xi* - A painted folding-screen treated as a Case Study on the Conservation of a Chinese Wallpainting in the beiwusheng huiguan, Ziyang.

In 2009 this sub-project was included into the German-Chinese Cooperation Project. Subject are the wall paintings in the *beiwusheng huiguan* in the village Wafangdian near Ziyang in the Shaanxi Province, China. This site derives from the Qing Dynasty and is situated on a former important trading post at the junction of three rivers. The *beiwusheng huiguan* comprises two building sections, one of which is decorated with skillful paintings. The cooperation work includes the investigation of all murals, the mapping and analysis of damages and the conservation and restoration work on one of the wall paintings as a case study. This report will first give an overview of the damages on the murals on this site and also illustrate their causes. The carrier is a three-layered plaster applied to a brick and adobe wall support. Two layers of clay plaster are covered by a clay-and-lime plaster. Within the carrier there were damages such as separation of layers which had resulted in voids, holes, scratches, dents, and washing down caused by a leaking roof. Caesuras from early furnishings are present, which are not damage. The priming layer consists mainly of kaolin-rich white earth and a natural binder. The paint layers are often extremely thin and as the white-earth priming is quite soft, this composite is easily damaged by mechanical impact. Apart from construction problems and mechanically induced damaging, there are impairments due to material ageing or the original manufacturing technique. In the case study on the mural named *pingfeng xi*, methods and materials for cleaning, conservation of the plasters, consolidation of paint layers and for retouching were investigated. The recipes chosen for plaster conservation were based mainly on natural materials like those which had also been used originally, such as loam, lime, straw, plant fibres and sand. This was an attempt to adapt to the properties of the original aged materials. Only in the case of grouting some modern additives were needed, such as glass bubbles and a cellulose derivate glue. The consolidation of paint layers was done with sturgeon glue and *Funori,* a Japanese algae glue. The paints for retouching were made from rabbit skin glue and stable pigments. The usage of all methods and materials used will be presented. The concept of retouching will show how decisions were made and what limits there are to retouching technique and to non-reconstructible areas. Finally the lost part of the first wing of the folding-screen, which had been destroyed by water from a leaking roof, will be reconstructed to achieve a well-balanced result.

Fig. 1
Photo taken in 2011, before cooperation work started on-site [Photo by Research Institute for Conservation of Cultural Heritage of Shaanxi Province].

CONDITION

In this section the condition of the murals will be presented. The damages and their causes as far as possible will be determined. The mural *pingfeng xi* was the most thoroughly examined of the nine murals in total in the *beiwusheng huiguan*. The reason for this is that *pingfeng xi* was chosen as a case study for conservation and restoration treatments during the cooperation project. Time was limited, therefore the other murals were only examined to a lesser extent in order to aid the understanding of the context. A mapping of damages, which gives an overview of their amount and distribution, is attached to this chapter. Mapping proves to be especially useful for invisible hollow areas (voids). Small-sized damages and losses of paint layer were not recorded in it, as it would have been too time-consuming.

Examination of Damages

The damages present have various causes. Soot and wax stains indicating the burning of incense sticks or candles in front of the paintings, however could originate from the time, when the building was still in its original use. Another cause is the changing usage, which started probably at the beginning of the 20thcentury.[1] Holes in all gable walls, graffiti and some of the stains originate from that time. In 1952, when the *beiwusheng huiguan* was turned into a grain distribution place, the buildings were changed according to their new purpose: Brick walls were erected in front of wooden doors of the transit hall, the main halls and the theatre buildings and inside the halls a wooden platform was built and the walls were panelled with wooden planks. From that time damages such as white wash on the upper part of the paintings on the gable walls of *zhengdian* (named *sanguo xi* and *sanguo dong*) derive.

[1] For further information see Final Report Part 1, p. 53 following.

During the most recent usage a heap of coal was stored along the northern façade of the *zhengdian*. This coal stock led to moist walls, and consequently to migration and accumulation of soluble salts: Rain water fell from the roof on the heap and got transported towards the wall. This caused damp walls and the migration of salts, which effloresced on both sides of the wall in a crescent shape.
In the south-eastern corner of the *guodian* building the roof had been damaged before its renewal in 2008. The impact of the damaged roof resulted in a partial loss of all three plaster layers on the left part of the mural *pingfeng xi,* along with a washed-off priming layer and lost paint layers in adjoining areas. Other damages of the paint layers resulted from the properties of the painting material used and its ageing behaviour.

Damages of the Carrier

Losses, scars and dents

Losses of one, two or even all three plaster layers are present. Depending on the severity of the damage, the 2nd or the 1st undercoats or even the brickwork is revealed. Where plaster is lost, paint layer is lost as well. Large-scaled, square meter-sized losses are caused by structural problems or damages of the buildings, as found in the *guodian* on *pingfeng xi* and on the north wall of *zhengdian*. Smaller or medium sized losses are often man-made, mechanically induced, such as holes from later construction work or damages from vandalism. A few small damages are a result of the original production technique, like cracks and detachments that occurred along originally produced plaster repairs. On the edges of plaster damages or losses the paint layers are often smashed, bulged or dented.
Pingfeng xi has a big loss of all plaster layers of fine coat and undercoats on the left hand side, going from bottom to top all across the mural; therefore the largest part of the first wing of the painted folding screen is lost. In adjoining areas, on top of still existing *fine coat*, priming layer and paint layer were washed away by rain water, which had been running down the wall. This loss was caused by a leaking roof in this area. This is documented by photographs taken at the time when the murals were revealed by removing the wooden panelling in the year 2008. The photographs show that plants have settled in front of the wall, growing on the washed down plaster remains (fig. 2, 3). After the removal of the wooden panelling, this loss had been filled up to the 1st undercoat level (fig. 4).
Scars and Dents
There are dented or scratched parts as well as losses that go half-way or completely through the fine coat layer, always also affecting also the paint layers. These mechanically induced damages predominate in the lower parts of the mural, parts which can be reached by a human from a standing position. Some of the damages were caused by accident, but there are also scratches (fig.8, 9), that were done as an act of vandalism (see corresponding passage on *vandalism* below).
Some scratches affected only the paint layer and did not go as deep as the *fine coat*. The priming layer consists mainly of kaolin-rich white earth and is therefore very soft[2]. Since most of the paint layer is also extremely thin, both are easily scarred or even scratched away. The softness of the materials is also the reason for dents (fig. 6, 7). The fine coat contains lime as binder and more sand and therefore is a bit more stable against mechanical impacts.[3] It has a higher compressive strength than the priming layer and the loam plasters of 1st and 2ndundercoat. The softness of clay minerals, enhanced by increasing humidity of air is the reason why surfaces of the murals could be easily dented. The paint layer and coat layers were deformed or pushed in and moved out of place.

[2] For details of composition of ground layer see *Final Report Part 1*, p. 75.
[3] For details of composition of fine coat see *Final Report Part 1*, p. 207.

Fig. 2
Photo taken in 2008 before the wooden panelling and additional walls (left and right) were removed, *pingfeng xi* is located behind the panelling. In the corner on the left the roof was leaking. [Photo provided by Mr. Jiangbo]

Fig. 3
Detail of the corner where the roof had been leaking. The water ingress let wood molder and washed off parts of the *pingfeng xi* mural. [Jiang Bo]

Fig. 4
After repairing the roof in 2008 the loss of plasters on the left was filled up to 2nd undercoat level. In adjoining areas, the priming layer has been washed off from the fine coat.

In the lower third of the *pingfeng xi* -, *pingfeng dong* and the *sanguo*-murals, man-made holes in varying sizes can be found. The diameters range from around 1–15 cm with depths up to 30 cm. Some of the holes are aligned (fig.5, 13). This gives evidence of constructions which were added later, but had already been removed, when the wooden panelling was built-in. However, there are also holes which do not follow a regular order. The smallest of these were probably caused by nails. At *pingfeng xi* (panel 2d), a small piece of wood was put into a hole and could have served as a dowel (fig.10, 12). This could be an original, constructional part, which was e.g. used for the scaffolding. In other holes, shards of tile had been inserted, for which an explanation regarding their function is missing (fig. 11).
The vertical edges of the protruding support of the murals were partly damaged by mechanical impact, which resulted in bumps. These damages are present on each gable wall in the *guodian* and on each *sanguo* mural in the *zhengdian.* The top edges of the murals in *guodian* have a brickwork cornice as a finish, which is painted grey with white joints, whereas in *zhengdian* the top edge and top side are uncovered. What the tops of the *zhengdian* murals originally looked like remains unidentified. The tops and top edges are often damaged, which could have happened during the removal of the wooden panelling. Photos with the still existing panelling show that it did not cover the walls from top to bottom. The top edge of the wooden panelling ends on the same level as the top edge of the *yunqi* murals. The *sanguo* walls, however protruded over the top of the panelling, so that the top area of the paintings were covered with white paint, when the panels were white-washed.[4] At the top of all murals some building material, likely a clay plaster, was used to bridge the gap between the built-in wooden panelling and brickwork wall (fig. 2).

Fig. 5

Pingfeng xi, the red lines sketch zones where holes are concentrated. They are not all exactly on the same level; still the holes seem to be in relation with some construction that has been there at a time.

[4] Photos of the *sanguo* murals can be found in *Final Report Part 1*, p. 36.

Fig. 6
Pingfeng xi detail 8d: In the green bush is a dented area, where the fine coat and paint layer is pushed in. On the bottom the dent is so bad, that the painted surface is ripped apart and displaced behind the surface level. Along the edge of this the painting and priming layer is bashed. Fibres of the fine coat are sticking out of the edges of the hole. The hole is caused by a pin or dowel. The lower edges of the hole are bulged and partly bashed.

Fig. 7
Pingfeng xi, detail of the framework: The fine coat and overlying paint layer is pushed in, along the edges the paint layer has broken apart.

▲ Fig. 9
Pingfeng xi, panel 6 d, detail of the man in the bottom left corner trying to melt the ice with his body, almost unreadable because of the damage by scratching.

▼Fig. 8
Pingfeng xi, panel 6 d, the man in the bottom left corner trying to melt the ice with his body is hardly visible because the area was severely scratched up. (Holes are already filled at this photo.)

Fig. 10
Pingfeng xi, panel 2 d, wooden stick in one of the holes.

Fig. 12
Wooden stick removed from the hole of *pingfeng xi*. The flattened end looks as if it was driven into the wall by a hammering tool.

Fig. 11
Pingfeng xi, shard of a tile in a hole.

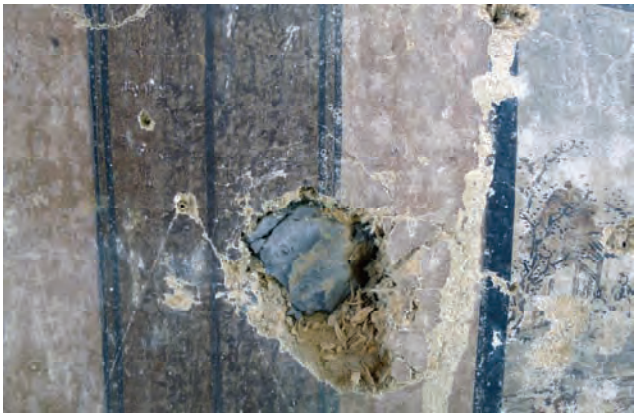


Fig. 13
Pingfeng xi, between panel c and d holes are arranged on a horizontal line.

Damages related to the original manufacturing technique

Original plaster repairs on *pingfeng xi* often show damages.[5] Along the edges of the repairs are often cracks and detachments of adjoining areas. The swelling properties of the repair plaster seems to differ from those of the fine coat plaster, so that the adhesion is weakened or gone. In *zhengdian* there are caesuras in the plaster coat, where the layers of the 2nd undercoat and fine coat are missing and which is not damage. These caesuras are evidence of installations, which are missing today. The 1st undercoat was applied before the installations were built-in, so that it can be found everywhere. But the 2nd undercoat and the fine coat are missing in vertical strips between the three murals of the north wall *tian guan cifu, pingfeng bei* and *long* due to vertical installations. Another caesura runs along the bottom of the murals of the north wall but also across the corners. It is also present on the bottom of the *yunqi* - murals due to the platform which was part of the furnishing built after the 1st undercoat was applied.[6]

Damp walls and soluble salts

More extensive plaster losses are recorded on the north wall of the *zhengdian*. Above the brickwork pedestal zone in the lower area of the murals *pingfeng bei* and *long* losses of fine coat and partially also 2nd undercoat occurred. Above the losses of the two murals, a whitish, crescent-shaped area with white efflorescence (fig. 14, 17) can be seen. In this whitish area, interfaces between plaster layers and also between first undercoat and brickwork support have partly lost contact, which resulted in large voids between different plaster layers. The plasters of the undercoats have a decreased structural cohesiveness, but the fine coat is still quite stable. At a closer look, white crystallized accumulations are visible in the plaster layers of the undercoats as well as on the interfaces between the undercoat layers and the fine coat (fig. 22). Components such as stones and straws are incrusted with white material (fig. 20). In a repair plaster between the murals *pingfeng bei* and *long*, losses in the shape of craters and white crystallized accumulations are present in the centre of the loss. It seems as if crystallisation burst the surface away (fig. 21). These damages and efflorescence correspond to the outside façade of this wall (fig. 15). The joints have white crystallised crusts and a few bricks have efflorescence on the surface. In one or two cases the surface of the bricks was damaged or even lost due to crystallisations, in most cases the joints are much more affected than bricks (fig. 18, 19).

The reason for this white efflorescence is a heap of coal which had still been stored on the outside of this wall when the roof was repaired in 2008 (fig. 16). The coal stock gathered the rain falling from the roof and directed the water towards the buildings' wall. The wall became wet and was also kept moist for some time by the coal. With the desiccation of the wall, water-soluble salts were transported towards the evaporation level on the painting's surface and the outer brickwork façade, where crystallization led to white efflorescence. The source of the salts could not be determined. One possibility is that they were already contained in the building materials; another is that they were dissolved in contaminated soil and were transported upwards through the brickwork wall. In raking light the surface of the mural *long* has a kind of rippled surface, altered by the former moist wall that caused swelling and shrinking resulting in this deformation (fig. 23). During the work stays the floor in the north-eastern area of *zheng dian* and also the eastern area of *guo dian* were often wet after heavy rain falls, but the pedestal zone did not seem to get moist anymore.

[5] For Repairs of the plaster layer see also *Final Report Part 1*, p. 75.
[6] Construction and original furnishing is described in *Final Report Part 1*, p. 71.

Fig. 14
Crescent-shaped white salt efflorescence on the north wall of *zhengdian*, in the area of *pingfeng bei* on the left and *long* on the right. In a large part of this area the plasters have separated on their interfaces due to moisture and salts. This led to losses in the lower part of these two murals.

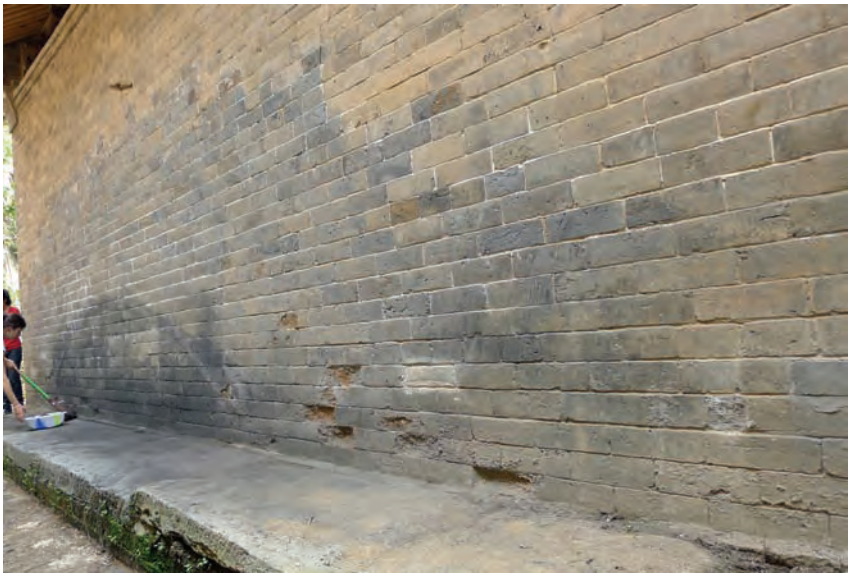


Fig. 15
On the façade of the north wall a crescent-shaped blackish area is present on which salts effloresced on joints and damaged bricks.

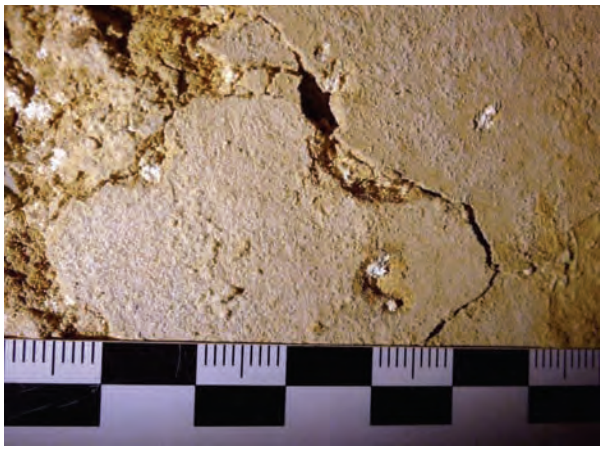
Fig. 16
Photo taken during the roof renewal in 2008, showing a coal stock outside *zhengdian*'s north wall [Photo provided by Mr. Jiangbo].

Fig. 17
Close-up of the bottom left part of *pingfeng bei*, white efflorescence on the painted and unpainted surface.

Fig. 18
North façade with white efflorescence along the joints.

Fig. 19
North façade: crumbly surface of a brick, which is affected by salts.

Fig. 20 Detail of lower long wall. The straw is incrusted with white material.



▲ Fig. 21
Detail of a repair plaster, with white salt effloresced on the surface and accumulations which led to crater-shaped losses. It seems as if salts have crystallized and by the uptake of volume have burst away the surface
Fig. 22 (top left)
Pingfeng bei, next to panel 6 d, in a close-up view. White crystallized salts enrichments are visible with the bare eye. Not only on the surface as in the top left corner of the photo but also within the plaster layers. The surface of the 2nd undercoat is cloudy white and crumbly.
.

▼Fig. 23
This is a close-up of the mural *long* taken in raking light. The painting did not only become whitish, but the surface became also wavy.

Voids

For an overview of size and distribution of voids please refer to the mapping of damages.
As described above in the section on moisture and salts *zhengdian*'s north wall has large areas of plaster voids due to moisture and salts. Additionally, voids were recorded in the corners of the north wall and on the edges directing towards former installations. Another phenomenon is that voids can be found around holes in the plasters, for example in the lower areas of the *sanguo* murals and the *guo dian pingfeng* murals, where a lot of holes and large areas of voids are present. These voids have probably developed from the materials' inconsistent behaviour towards climatic changes. Compared to the plaster, the wooden pins or dowels sticking inside the holes changed their volume at a different rate. Being rigid they disturbed the plaster's changes in volume parallel to its surface. The pins or dowels also had a different dimensional change orthogonally to the plaster's surface. These two problems paired with pulling strength powers when removing pins or nails led to detachments around the holes or, with many holes present, even to extensive detachments of the perforated areas.
Voids have formed on the interfaces of the overlaying plaster layers or brickwork, sometimes also lying upon others at different levels.

Damages of the Paint Layer

There are different reasons for damaged paint layer. Mechanical damaging such as scratching, denting or holes were described before, as these often also damaged the coat layers below. Damages that are predominantly restricted to the paint layers will be described and problems linked to a particular paint layer or area will be explained in the following.
Flaking paint layers resulting in losses occur on the *sanguo*-walls particularly where red paint or gilding was used, on the *pingfeng xi* and *dong* walls at the green dots, painted where nature is depicted, at the flower borders and at *pingfeng xi*'s e-panels. Powdering paint exists, particularly on the *pingfeng bei* wall, where the wall was damp and a salt load is present. It is likely that also colour changes, such as fading have happened, as some areas appear strangely whitish today. For example the dragon's breath on the painting *long*. In visible light the colour of the breath and the surrounding areas look the same, with an off-white painted breath on an off-white coloured background. Examined under UV light, completely different fluorescence of breath and background appears, which could be due to differing binding media. The painter could have used two different white paints in order to achieve a varied shine on both parts or a change in colour could also be possible here.[1]

Graffiti and other Vandalism

There are damages of the painting that were caused by vandalism. People made holes, scratched or scorched areas and made drawings or graffiti using various media. Mainly the two folding screens in *guodian* are affected by these kinds of damages. Some figures' were targeted for damages, resulting in pierced figure's eyes and scorch marks which were probably caused with a cigarette or something similar (fig. 24−28).The graffiti were made with chalk or pencil, most of them, however, were done with black paint or ink (fig. 29−31). These black graffiti are letterings or sometimes small drawings with paint splatters.

[1] See also *Final Report Part 1*, p. 169.

Fig. 24
Detail of a man in *pingfeng dong* panel 4 d. Holes are pricked into the face and eyes are circled with ink or paint.

Fig. 25
Detail of a man in *pingfeng dong* panel 8 d, both eyes are pricked.

Fig. 26
Man with a burnt part in his face, *pingfeng xi* panel 2d.

Fig. 27
Lady with a burnt part in her face, *pingfeng xi* panel 5d.

Fig. 28
Man with a burnt part in his face, *pingfeng xi* panel 5d.

Fig. 29
Detail of *pingfeng dong* panel 3b, graffiti with chalk.

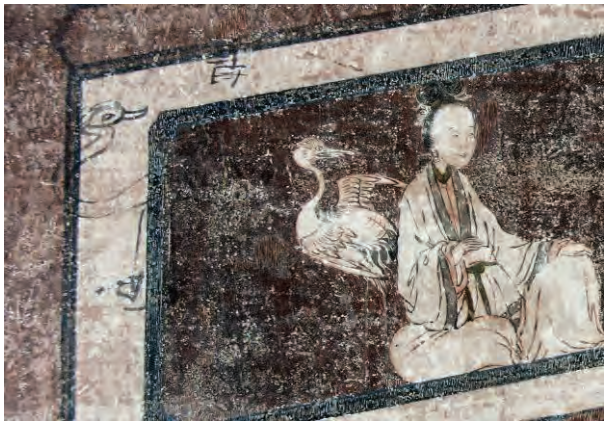


Fig. 32
Detail of *pingfeng xi* panel 5 d, pencil graffiti.

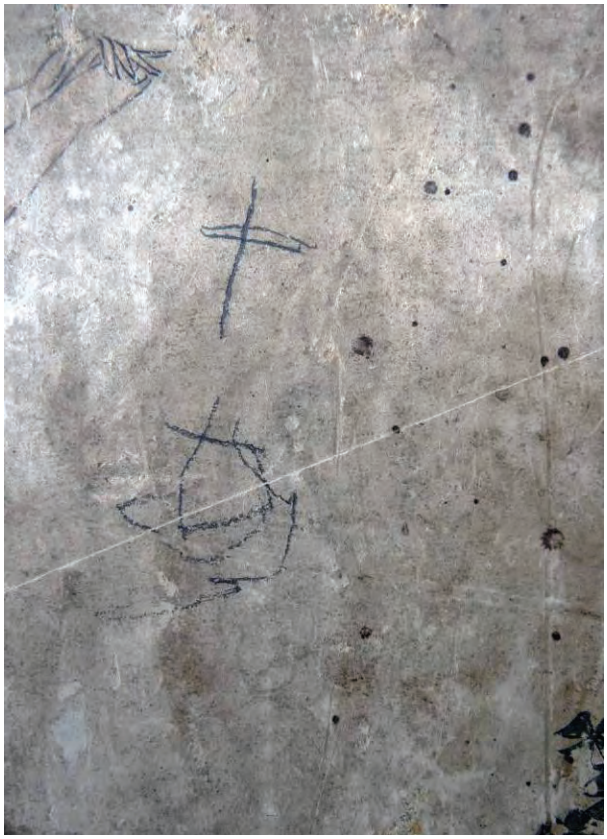
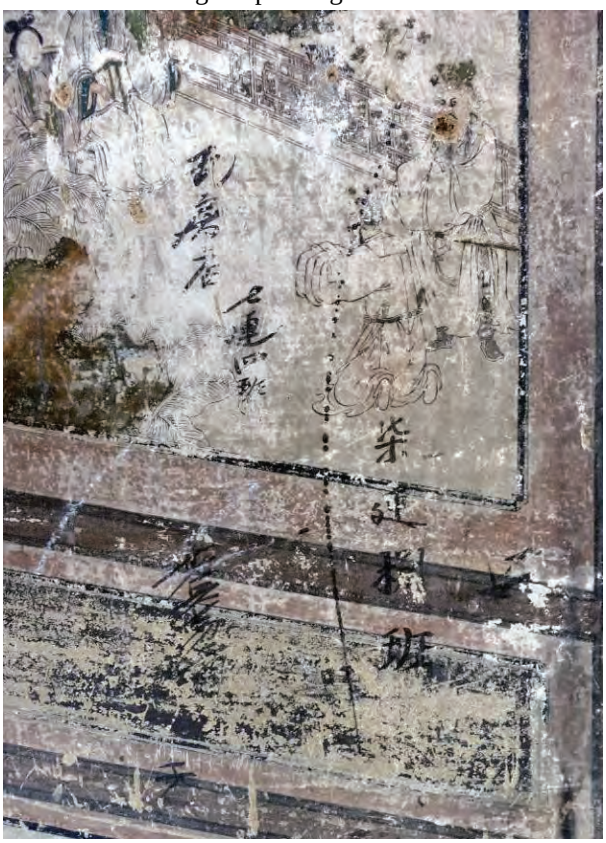


Fig. 30
Pingfeng xi, next to panel 8a/b: The light grey to white background colour next to the folding screen is at the same time the priming layer for other paints. In parts blisters and detachments from the fine coat can be seen, which resulted in losses.

◀Fig. 31
Pingfeng xi panel 7 d/7 e, graffiti lettering and paint-splatter in ink.

▼Fig. 33
Detail of *pingfeng xi* panel 2c, a graffiti repeating the crane from the original painting



Losses of paint layer

White background and priming layer
The light grey to white background colour next to the folding screen is also in other places of the mural as the priming layer for the other painting colours. Between the framework and the black framing this white to light grey layer has partly blistered and detached from the fine coat, which resulted in losses (fig. 30).

Green Paint
Many of the green dots, found in large numbers all over the murals are detached, fragmented or completely lost (fig. 35, 36). The green paint is rather stiff and has a good cohesion. Its thermal or hygric properties must be different from the layer beneath, so that starting from the edges of the dots the green paint peels off the carrier substance and finally falls off. Sometimes a little green paint remains in the centre of the dot.

Red Paint
The flower-and-star-border of *pingfeng xi* has a distinctive pattern of damage. Losses derive from the dark red paint, which is present in the centre of the points of the stars and in the red centres of the small flowers (fig. 37, 38). Due to tensions within the red paint layer and on the interface between the priming layer and fine coat the red paint has flaked off. The detachment happened between priming layer and fine coat, although it was caused by the application of the red paint. In the loss one can see that the binder of the dark red paint has soaked and penetrated the priming layer. The permeated binder of the red paint is visible as a shadow in a distinctive shape on the exposed fine coat surface. The light red or pinkish paint around the red centres has partly the same problem. The blue paint has a better adhesion to the support, though in places it got peeled off by the flaking red layer together with the priming layer. The cohesion within the paint layer composite and the adhesion to the priming layer is stronger than the adhesion to the fine coat.
The red paint in the flower-and-star-borders of *pingfeng xi* and the red paint on the *sanguo* murals have similar problems. The red paint layer has cracked into small fragments, which edges partially coiled up (fig. 39, 40). This could be due to swelling and shrinking with climatic changes or to the binding medium of the red layer. It could be more sensitive to ageing than most of the other paints' binders or be present in a higher amount in relation to the pigment. Another factor could be the thickness of the layer, as in a thicker layer tensions can grow stronger than in thinly applied layers.

Gold
Applications of gold on the murals *sanguo xi* and *sanguo dong* are often lost. At places, where gold was applied on fine ornaments it is lost today with the surrounding paint layers still intact (fig. 41). This damage is linked to the painting technique. The properties of the mordant are the problem, so that the gold layer together with mordant cracks and finally separates from the priming layer.

Fig. 34
Pingfeng xi, panel a, the black filling frame paint has a whitish blurred surface and some losses.

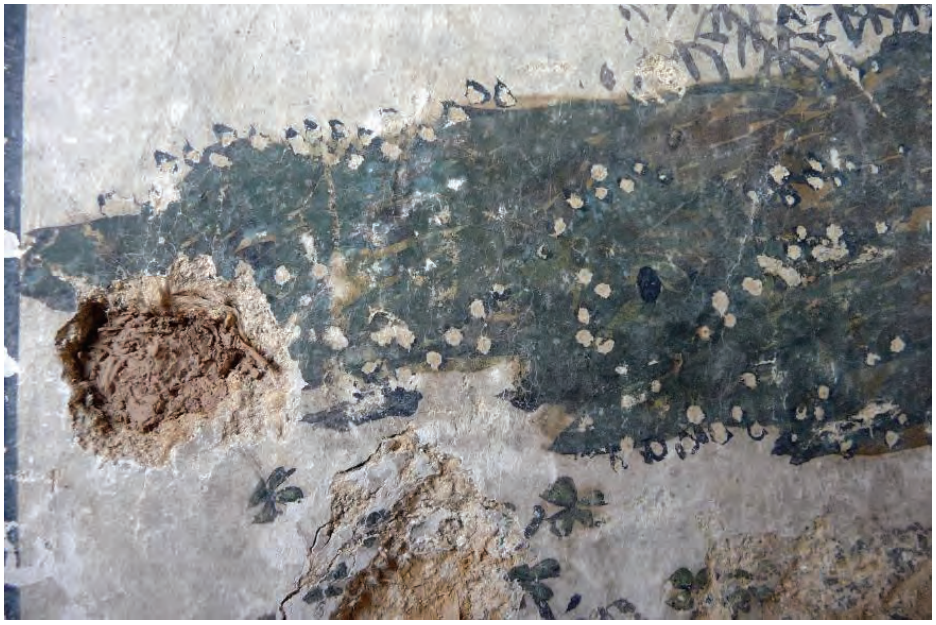


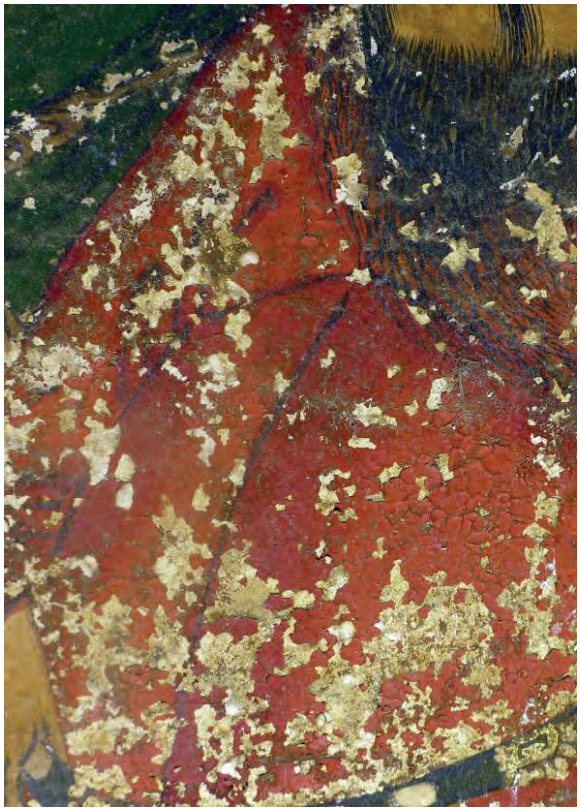
Fig. 35
Pingfeng xi, the green dots are almost entirely lost; a light fine coat-coloured dot pattern has remained.

Fig. 36
Pingfeng xi, three green dots getting detached from the edges. Some material of the top green dot is already lost.

Fig. 37 , 38 ►
Pingfeng xi panel 4 b: Damages of paint layer in the flower-and-star-border began from the red paint of the points of the stars and from the red centre of the flowers. In the exposed fine coat the shape of the former dark red area of the star is visible. The binder of the red paint has permeated the priming layer and left dark marks on the fine coat.

Fig. 39
Sanguo xi, red paint flaking off CaoCao's robe.

Fig. 40
Sanguo xi close-up, the red paint has cracked to small fragments; edges of fragments started coiling up.



Paint layer in pingfeng xi's e-panels (dark brown, black and yellow paint)

The paint layer of the e-panel fillings on *pingefeng xi* are in a fragmented condition. The dark brown paint, which is the background fill colour has flaked off in several panels largely along with the priming layer. In panel e almost no painting material is preserved and the fine coat surface is revealed (fig. 9). In very small areas remains of a yellow paint can be observed, giving evidence of a bright yellow ornament, which had been present here before, just like it is still today on *pingfeng bei* (fig. 98, 99). The flaking off background has a distinct pattern in some of the e-panels, especially in 8 e. The losses are in the shape of an angular ornament (*yun leiwen* ornament), an ornament that was present earlier than the yellow one. The adhesion of the paint used for this ornament is even worse than that of the background fill paint. (fig. 18). Because of this damage the *yun leiwen* ornament is well noticeable. The black filling frames are damaged along with the panel fillings. The remaining paint layer fragments have a craquelé and adhesion to the fine coat, or to the sizing layer on the fine coat is poor. It is remarkable that the damage is less than in the area close to the left hand side, where the water ingress from the leaking roof took place (fig. 1).

Black paint

One of the black paints on *pingfeng xi* which has been used for the black filling frames of the panels a and d shows a distinctive deterioration, compared to the black fill that has been applied on top of the contour lining. The black fill paint does not have good adhesion to the carrier, so that fragments got lost. The surface of this paint has altered and turned whitish in some other parts. Compared to the other black paint used on *pingfeng xi* it seems more sensitive to water and gets blurred by it (fig. 34)

Painting materials of the *Long* mural are also extremely sensitive to water. The mural, depicting dragons, shows traces of former water ingress below the top edge of the painting. The water has not only washed down dirt but also water-soluble parts of the paint layer (fig. 42).

Discolouration

The pastose blue paint used for details in the panels has a darkened surface because its binding medium has turned dark with ageing. The original bright blue of the paint can be observed where the surface of the paint layer is damaged (fig. 43, 44). The blue pigment is quite coarse, the grainy texture is visible with the bare eye.

The pastose green paint used for details of robes, architecture, objects and landscape in *pingfeng xi* has a brownish discoloured surface. Where the discoloured surface of a layer is scratched it is bright turquoise green underneath. Landscape parts are coloured with washes that today appear in a brownish olive-green hue. These areas could also have been of a brighter hue in the beginning.

Where green paint is used for landscapes it is always accompanied by a brown transparent wash. The landscape areas are without fluorescence in UV examination and appear dark. This is typical for Cu- and Fe pigments. The brown wash prevents UV-fluorescence even where it is so thin that it is almost not noticeable as green in visible light.

Fig. 41
Sanguo xi close up of a rider: Gold applications such as ornaments on the hat, the chest, the shoulder armour and on the belt got lost.

▼Fig. 42
Long, marks from water which has washed down water-soluble parts of paint layer.

Fig. 43
Pingfeng xi close up of panel 7d, the headgear of the old lady is blue with a dark grey surface. The olive green furnishing beside her head has a bruised spot next to her eye, which looks bright turquoise green.

▼Fig. 44
Pingfeng xi close-up of panel 8d, next to the vessel is a casket with a blue top. The blue pigment looks dark grey where it is coarse-grained, but bright blue where it is bruised.

Fig. 45
Pingfeng x, panel 7 a/b, a splatter of white paint.

Fig. 46
Pingfeng x, panel 7 a/b, splatters of grey paint from the renewal of the cornice on top of the mural.

◄ Fig. 47
Marks from washed up dust or clay where water was running down, can be found all along the top edge of *pingfeng xi.*

Fig. 48
Pingfeng xi, above the 6th wing of the painted folding screen, remains of light brown paper on the surface.

Fig. 49
Pingfeng dong, panel 6 e, greyish paper stuck onto the painting.

Soiling and Stains

On *pingfeng xi* different stains and soiling was found. The surface was covered with a layer of fine-grained heavy dust. Some excrement from birds or bats sticking to the surface could also be found. In the lower area were several stains from a thick but rather soft whitish material, which could have been wax. Apart from splatters from the graffiti paint mentioned above also splatters from other paints, probably deriving from more recent repainting of the hall's architecture can be seen. (fig. 45, 46).

Running marks caused by water indicate a leaking roof in former times. Besides the water marks next to the large loss caused by water ingress on the left of *pingfeng xi*, more marks along the whole top edge of the mural can be seen by traces of dust or clay. In the light coloured backgrounds of *pingfeng xi*'s panels d and e some drop-shaped marks are visible. These were probably caused by water or happened during a careless application of a transparent material during working process, maybe also a combination of both.[2] These marks are explained in the section on the investigation of painting technique.

A type of clay plaster, which had been used to fill holes, was smeared inappropriately beyond holes onto intact and painted surface. This also happened to some of the other murals. This was probably done before the year 1954, the year when the wooden panelling for the grain storage was installed (fig. 47, 50). The clay was sticking very strongly to the painting and damaged the paint layer, when it was taken off without care.

Some areas of the guo dian murals have paper remains sticking to the surface. Above *pingfeng xi*'s wings number 5, 6 and 7 are brownish paper remains, within the panel 2 e and 3 e are greyish remains (fig. 48, 50). On *pingfeng dong* bigger remains of paper can be seen in the lower section of the mural, on the level of panels e and d (fig. 49, 52).

In the lower part of *pingfeng xi*, in the area of the e-panels and nearby above and below, several stains were directly or indirectly caused by heat or fire. Several grey to black stains in the shape of flames are likely deposits from something like candle flames or smouldering incense sticks (fig. 51, 53). In one of these flame-shaped stains, the heat seems to have had impact on the colour of the paint.[3] The normally black paint seems to have changed to red due to the heat, or it was prevented from turning black in this area. In the d-panels of *pingfeng xi* dark stains were caused by something that burned the surface directly and therefore scorched it. This damage can be observed mainly in the figures' faces of the d-panels. This was categorised as an act of vandalism and described above (fig. 26−28).

[2] See also *Final Report Part 1*, p. 113−115.
[3] See also *Final Report Part 1*, p. 129.

Fig. 50
Pingfeng xi, above panel 7a, fibrous material like paper under a nail head. Washed up dust or clay in line where water was running down.

Fig. 52
Pingfeng dong, panel 5 d brownish paper with letterings glued onto the painting's surface.

Fig. 51
Soot stain in panel 3e, it seems that heat caused a change in the paint from black to red.

Fig. 53
Soot stain on the edge of panel 3e.

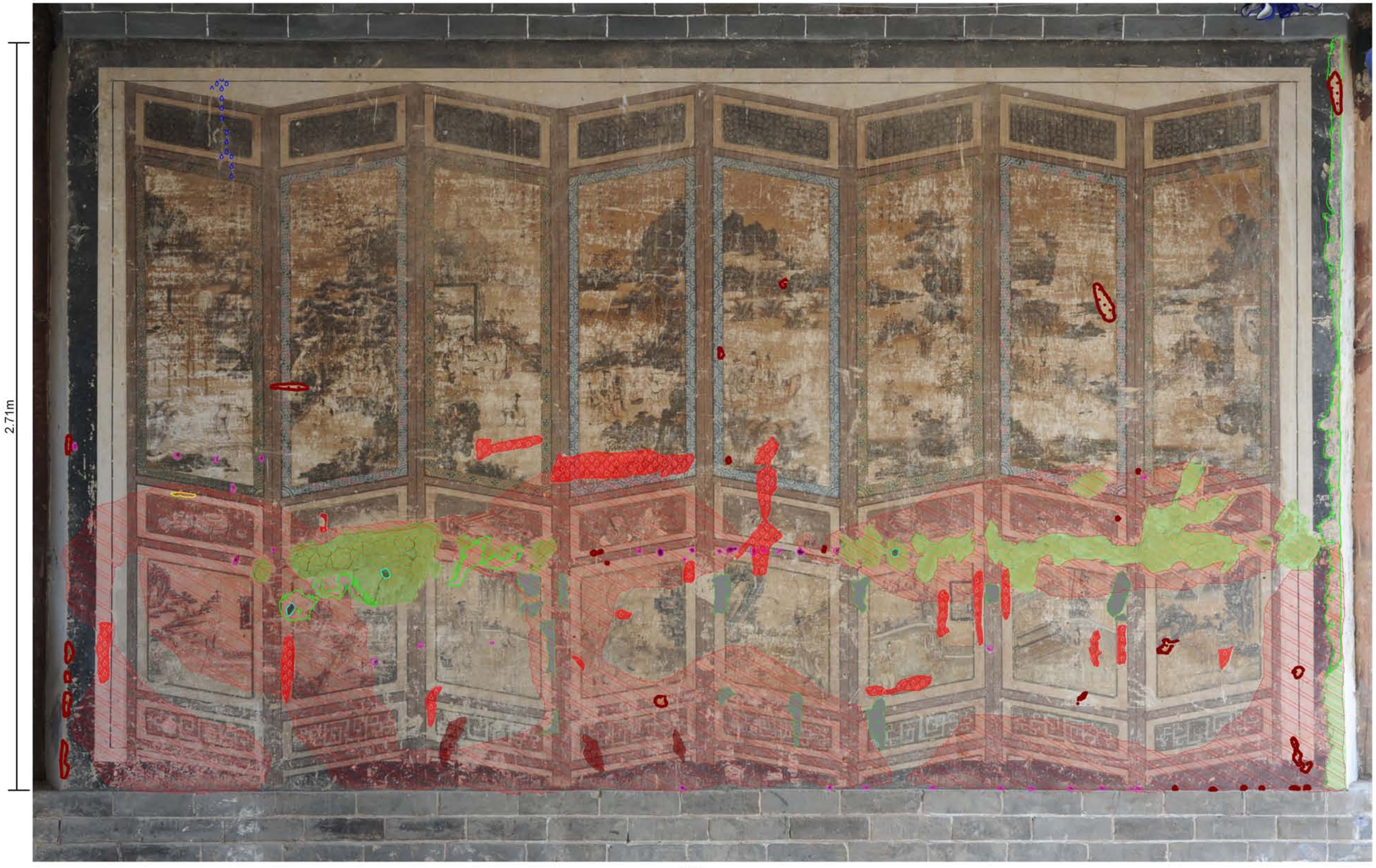
Mapping of damages

PINGFENG XI - Mapping of Damages - August 2011

Legend Damages

- Cavern
- Holes
- Loss of 1st Coarse Coat
- Loss of 2nd Coarse Coat
- Loss of Fine Coat
- Damaged Fine Coat
- Scratches
- Dented Surface
- Repair Filling
- Clay on Surface
- Soot Stains
- Graffiti
- Wooden Pin
- Shard of Tile

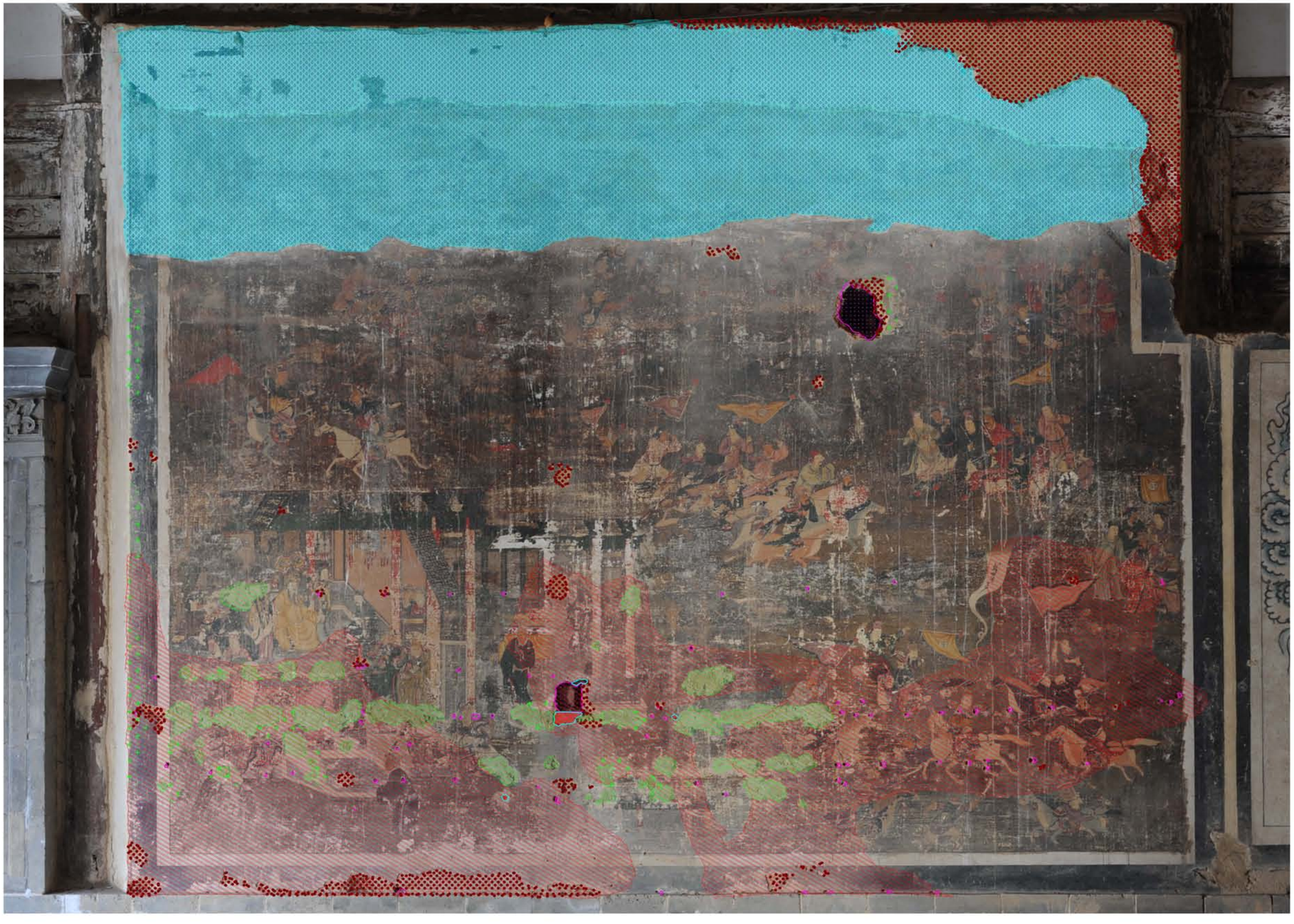
PINGFENG DONG - Mapping of Damages - August 2011



Legend Damages

- Holes
- Loss of Fine Coat
- Cavern
- Scratches
- Repair Filling
- Clay on Surface
- Soot Stains
- Paper on Surface
- Graffiti
- Water Marks
- Shard of Tile

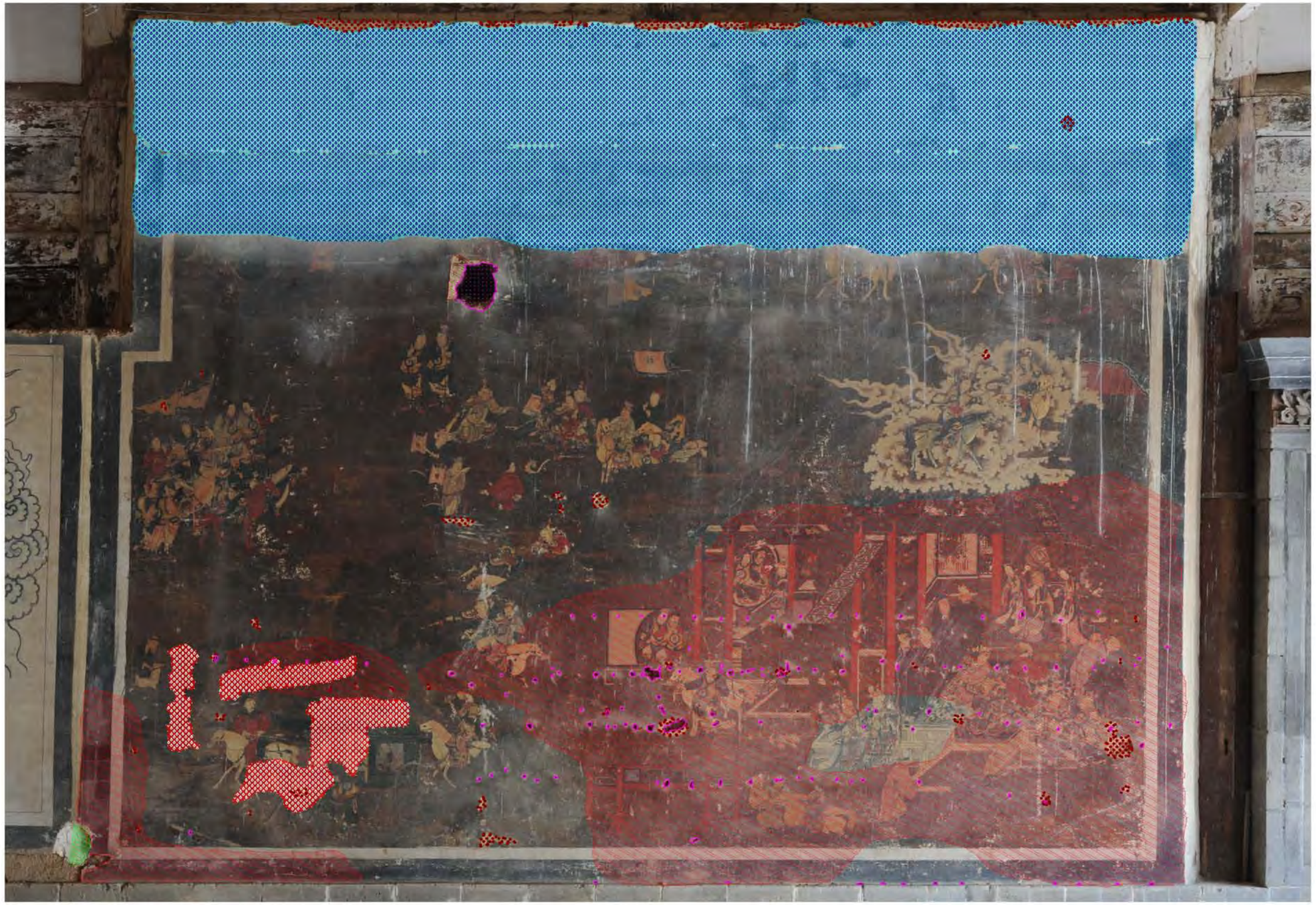
SANGUO XI - Mapping of Damages - August 2011



Legend Damages

- Holes
- Loss of Fine Coat
- Loss of 2nd Coarse Coat
- Loss of 1st Coarse Coat
- Cavern
- Repair Filling
- Clay on Surface
- Covering White-wash
- Wooden Pin
- Shard of Tile

SANGUO DONG - Mapping of Damages - August 2011



Legend Damages

- Holes
- Loss of Fine Coat
- Loss of 2nd Coarse Coat
- Loss of 1st Coarse Coat
- Cavern
- Filling
- Graffiti
- Covering White-wash

TIAN GUAN CI FU - Mapping of Damages - August 2011

Legend Damages

- Loss of Fine Coat
- Loss of 1st Coarse Coat
- Loss of 2nd Coarse Coat
- Cavern
- Repair Filling
- Clay on Surface

PINGFENG BEI - Mapping of Damages - August 2011

Legend Damages

- Loss of Fine Coat
- Loss of 2nd Coarse Coat
- Loss of 1st Coarse Coat
- Cavern
- Flaking
- Repair Filling
- White Efflorescence

LONG - Mapping of Damages - August 2011

Legend Damages

- Loss of Fine Coat
- Loss of 1st Coarse Coat
- Cavern
- Repair Filling
- Clay on Surface
- White Efflorescence
- Water Marks

YUNQI XI - Mapping of Damages - August 2011

Legend Damages

- Loss of Fine Coat
- Loss of 1st Coarse Coat
- Cavern
- Repair Filling

YUNQI DONG - Mapping of Damages - August 2011

CONSERVATION AND RESTORATION TREATMENTS

Conservation and Restoration of the wallpainting *pingfeng xi* comprised the following steps

- Cleaning
- Consolidation of paint layers
- Consolidation and grouting of plaster voids
- Filling losses in the coarse coats and fine coat
- Integrating losses in the paint layer by retouching
- Reconstructing a lost part of the left wing of the painted folding screen

At the end of the treatment report is a mapping of treatments attached.

Cleaning

Gentle cleaning methods were needed as the soft priming layer is made of kaoline and the paint layers are thin and could therefore easily scratched. Only areas with thicker paint layers, e.g. flower boarders and the black framing were less sensitive to mechanical impact.
Tests on sensitivity of the paint layer towards solvents were conducted before cleaning. It showed that the painting materials are sensitive to water, as well as to solvents like ethyl alcohol, acetone, ethyl acetate. Hexane, another solvent we could obtain, did not affect the painting materials but had also no cleaning effect.
The first step of cleaning was dusting off with a soft brush. By this means loose dust and spider-webs could be removed, but the surface of the whole painting was still covered with a thin layer of very fine dust.
Therefore another gentle and efficient dry cleaning method was needed. Two types of dry cleaning sponges „Wallmaster“ and „Akapad soft“[1] (fig. 57), were tested, both made from latex foam. The „Wallmaster“ sponge was considered being too soft, as it had to be rubbed over the surface to get a good cleaning result. The „Akapad“ sponge cleaning could be carried out by „rolling“ pieces of the sponge over the surface, so that it had no or little impact on the paint surface. Therefore, the cleaning of the whole *pingfeng xi* painting was conducted using the product „Akapad soft“, which led to a satisfactory clean surface (fig. 54, 55, 56)

Clay soiling was another issue which originated from inappropriate repair fillings with clay smeared across the edge of losses onto the painting (fig. 60). The soiling adhered strongly to the painted surface, therefore taking it off mechanically was not possible because removing the clay resulted in splitting off the adhering painted surface with the priming layer. Consequently, thick lumps of clay were bit by bit thinned from the top. The clay was carefully wetted with a mixture of water and alcohol (mixed in parts 1:1), so that the underlying painting and priming layer did not get affected. This helped to soften the clay and reduced its cohesion. The clay was then thinned with scalpels and could be removed in a controlled way, using a horn spatula near the painting’s surface. This spatula was originally a cosmetic tool to clean and remove cuticle on finger nails. It was modified, so that it had a sharp and flexible end like a knife. It was used because metal spatulas and scalpels damaged the painting too easily. The last remaining thin layer of clay was then cleaned with „Akapad soft“ sponges (fig. 61).

[1] The sponges were provided by the Company „Deffner & Johann GmbH“, address: Muehlaeckerstr. 13, 97520 Roethlein, Germany, URL: http://www.deffner-johann.de.

The Chinese colleagues wanted the numerous Graffiti to be removed or become illegible. Graffiti made from chalk was easily removed with the dry cleaning sponges. Graffiti made of other material could not be removed, although different approaches were tried. Cleaning with erasers led to damage of paint and priming layer. An eraser pen (Faber-Castell/Perfektion 7057) was tested and considered unsuitable. It was possible to reduce some of the graffiti paint with it, but at the same time the soft priming layer underneath was compressed and its surface gloss changed. The graffiti made with ink seem to have been carried out with different paints. Some were not affected by water at all, but some could be reduced a little with moist cotton swabs (fig. 58, 59). The paint also permeated layers of the painting and of priming layer, however, so the graffiti could not be taken off without damaging those. Since there was no possibility to clean or take off the Graffiti without damaging the mural, retouching was chosen as a way to conceal them and match these areas with the surrounding. Paint stains and soot, which has permeated into the painting layers, could also not be removed, but stains from waxy material could be removed with hexane. Paper sticking on the surface was lightly wetted and could then be taken off with the help of a wooden tool and the horn spatula.

Consolidation of paint layer

Especially the flower borders and green dots which can be found all over the painting and the dark brown backgrounds of the c- and e-panels needed consolidation. Flakes of paint detached due to tensions within the layer and adjoining parts were prone to falling off as well. The consolidation and reattaching to the support was done with sturgeon glue, modified with Fu Nori. The concentration used was 3 % - containing two parts sturgeon glue and one part Fu Nori.[2] The sturgeon glue has good properties, such as good adhesive strength, elasticity and low viscosity for good penetration behaviour. The modification with Fu nori makes the consolidant dry matte and increases its viscosity, so that the consolidant does not permeate the priming layer too fast. The consolidant was applied warm with a small brush. In a second step, the flakes were pressed down with a heated spatula where heat was needed. A piece of Evolon® mat was used in between the spatula and the paint layer surface (fig. 62).Where no heat was needed, for example for the consolidation of c- and e-panels, colourshapers with silicone tip stamps made from Melinex foil cushioned with cotton were used.

[2] Fu-Nori was provided by the Company „Kremer Pigmente GmbH & Co. KG“, address: Hauptstr. 41 – 47, 88317 Aichstetten, Germany, URL: http://kremer-pigmente.de/en. and Sturgeon Glue provided by „Stoerleim-Manufaktur Eva Przybylo“, address: In der Helle 21, 59929 Brilon, Germany, URL: http://www.stoerleim-manufaktur.de.

Fig. 54
pingfeng xi panel 5d/6b during cleaning, the right half shows the first step after dusting off with a soft brush, the left half is already cleaned dry a second time with dry-cleaning sponge named “Akapad@ soft”.

Fig. 55
pingfeng xi detail of panel 5c, left half already cleaned with the dry-cleaning sponge named Akapad@ soft.

▼ Fig. 56
pingfeng xi panel 2 b to 3 b, in the right half of the photo the painting is still covered with a thin layer of dust, the left half it is already cleaned with the dry-cleaning sponge named “Akapad@ soft”.

◄ Fig. 57
Photo of dry-cleaning sponge Akapad® soft, used for cleaning, source: http://www.akachemie.de, October 2013

Fig. 58
pingfeng xi panel 7d, splatters of ink from a graffiti.

Fig. 59
pingfeng xi panel 7d, the two splatters of ink on the bottom were reduced with a damp cotton swab.

Fig. 60
pingfeng xi panel 2d, detail of an old repair filling, clay smeared across the edge of the loss onto the painting.

Fig. 61
pingfeng xi panel 2d, detail after removal of the inappropriate old clay repair filling.

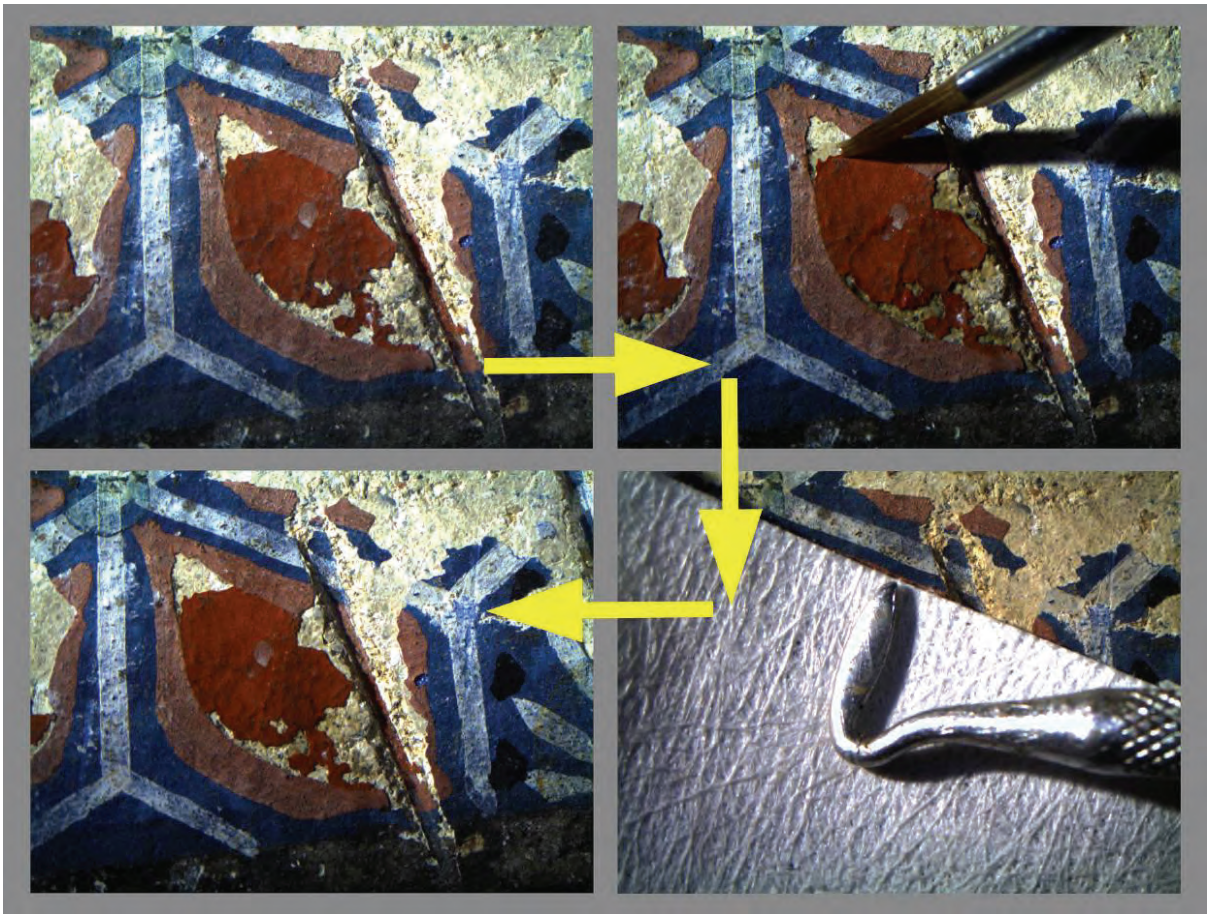


Fig. 62
Consolidation of paint layer: Application of consolidant (sturgeon glue, Funori) with a brush and reattaching delaminated layers with the help of a heated spatula and through an Evolon® mat.

Conservation of Plaster

After cleaning and Consolidation of paint layers was carried out in 2011, the main focus was the conservation of the carrier of the painting for the work stay in 2012: The multi-layered plaster is affected by delaminating layers, bulging and voids and different scaled losses needed treatment. For hollow areas in the plaster, for voids in between separated plaster layers an adequate grouting material was to be found, to fill and to re-adhere the layers again with each other. Loam, being main component of the plaster layers should also become a component of the grouting material. On this base modifications regarding to fillers and additives are possible. To develop a new plaster grouting needs time for laboratory and material testing and detailed examination of the composition of the original plasters [1] Both we had a lack of. We didn't examine the plaster properties elaborately, as it was not possible to take bigger samples. Furthermore loam is different from every site it has been taken from. Testing would have to be carried out with Chinese local loam. As time was a bit short we started a practical approach and researched for conservation projects where comparable problems were dealt and solved. The difficulties and requirements were considered and transferable treatment methods and materials selected which could come into account for the conservation of the murals in Ziyang. Then preliminary tests were carried out in the workshop in Germany on mock-ups for comparison of workability and properties. During the work stay of August and September 2012 more tests were to be carried out with local building materials. After successful testing the methods and materials were to be carried out on the murals *pingfeng xi.*

Tests for grouting

For grouting voids we found three recipes from other conservation projects, where clay plasters needed grouting that cold serve as a starting point. These projects, in which a comparable problem was treated were a sino-american Cooperation Project with Getty Conservation Institute on “Cave 85 in Dunhuang”[2], another sino-german Cooperation Project at the Technical University Munich on the temple “Shuilu'an”[3] in Lantian and a diploma thesis by Gesa Schwantes in Bern, Switzerland dealing with the conservation of loam plaster as carrier of wallpainting in the asian region.[4]

The requirements for the grouting material needed for our purposes were good adhesion to the old plaster in the void, adequate cohesion or strength, little shrinkage when drying, viscosity high enough to fill also bigger gaps and physical properties that are close to the original

[1] A detailed description and instruction of how to develop a grouting for earthen plasters is made by Daniela Geyer in her thesis carried out in the Rathgen Forschungslabor Berlin: GEYER**,** Daniela: „Vergleichende Erprobung von Injektionsmassen auf Lehmbasis für die Konservierung von historischen Lehmbauten“, 2007.

[2] Grouting recipe 2 was copied from: Rickerby, Stephen/ Shekede, Lisa/ Fan Zaixuan/ Tang Wei/ Qiao Hai/ Yang Jinjian/ Piqué, Francesca: „Development and Testing of the Grouting and Soluble-Salts Reduction Treatments of Cave 85 Wall Paintings“, in: „Conservation of Ancient Sites on the Silk Road, published by Neville Agnew, Getty Conservation Institute, Los Angeles 2010, p 471 – 479.

[3] This Grouting recipe (Grouting 1) was copied from another sino-german Cooperation Project at the Technical University Munich on the temple Shuilu'an. The development of this recipe is written down by Holl, Kristina: „Tests on clay mortars for the Shuilu hall“, in: „Shuilu'an – Annual Report 2007 – 2009“, published by Technical University Munich 2010, p. 49 – 65.

[4] Grouting recipe 6 was copied from Schwantes, Gesa: „Konservierung von Lehmmoertel als Traeger von Wandmalereien im asiatischen Raum“, diploma thesis at Hochschule der Kuenste Bern, Switzerland, 2006.

material. Furthermore the grouting should have a good injectability through cannulae (diameter of 1,2 mm) as well as small tubes (diameter of 3 mm).
It was assumed that two or three different grouts would be needed, with different conditions and behaviours. One to bridges bigger gaps and one type in a fluid condition to flow well and fill thinner voids over a large area. The murals on the north wall with the load of soluble salts, have a further problem. There are large areas of thin voids that needed grouting, but here the 2nd coarse coat layer has a lack of cohesion, so that a grouting is needed that can attach or even consolidate the crumbly substrate. Or the void needs to be consolidated before grouting could be carried out here.
On the base of the grouting recipes from the other projects we started testing and modifying. All grouting materials consisted of loam, one or two inorganic fillers, an additive and water.
The first tests were carried out in Germany and later on-site tests were carried out with loam, which we took from the surrounding countryside. The tested grouting recipes are listed in the table following:

Table 1: Tested grouting recipes

Name of Recipe	***Loam***	***Aggregates***	***Water***	***Organic additive***
Grouting 1 (Shuilu'an)	*6 VP*	*15 VP Microballoons*	*5 VP*	*2 VP Methylhydroxyethylcellulose (3% in Water)*
Grouting 2 (Dunhuang)	*1 VP*	*2 VP Microballoons 1 VP Sieved pumice(150 - 75μm)*	*0,66 VP*	*5% of the dry components whisked egg white added*
Grouting 3 (modified. Grouting 2)	*1 VP*	*2 VP Microballoons 1 VP Sieved pumice(150 - 75μm)*	*1 VP*	*0,4 VP Methylhydroxyethylcellulose "Tylose MH 300" (3% in Water)*
Grouting 4 (modified. Grouting 2)	*1 VP*	*2 VP Microballoons 1 VP Sieved pumice(150 - 75μm)*	*1 VP*	*0,4 VP Rabbit Hide Glue (3% in Water)*
Grouting 5 (modified. Grouting 2)	*1 VP*	*2 VP Microballoons 1 VP Sieved Quartz sand (<0,2mm)*	*1 VP*	*0,4 VP Rabbit Hide Glue (3% in Water)*
Grouting 6 (diploma SCHWANTES)	*1 VP*	*1,5 VP Quartz sand 0,08 - 0,2 mm*	-	*0,5 VP Polyvinylalcohol 4-88 dissolved in water (4%)*

VP i.e. Volume Parts

Tests with Chinese loam

In the first test we filled the grouting materials with a spatula into a cylindric mould with a diameter of 5 cm, which had been placed onto an adobe brick that was wetted with water and ethanol (1:1 VP). By this means we created cylindric test samples (fig.63, 64). It was observed how the grouting would attach to the adobe and how badly it shrinks (table 2). In the second test their injectability through tubes and cannulae was observed, to check the workability of the grouting (table 3). If the material wouldn't be injectable, it was diluted with water until it became injectable. Then a second test piece was poured into the cylindric mould to see if the shrinking behaviour has changed. Next the flow ability of the grouting was tested. For this the grouting was poured with a syringe and tube onto a vertical adobe surface. The flow-ability was judged by the length of the material flowing down vertically (fig. 62).

Last we tested the practical usability with void models. Two boards equipped with plaster were attached to each other with clamps and with distant holders in between. Holes of 4 mm diameter were drilled into one of the boards. The boards were put in a vertical upright position and step by step the grouts were injected in separate holes. Furthermore each void was, wetted with a mixture of water and ethanol (1:1) before. Fluidity or flow behaviour in the void and adhesion to the void surfaces were observed (fig. 65, table 4). These kind of void models had been made in Germany in advance, and later on site again with the groutings made from local loam.

Table 2: Observations on cylindric test samples

Grouting	***Visual evaluation of cylindric test mould***	***Adhesion***	***Comments***
1	*Little shrinkage*	*good*	*Can be torn off from the adobe surface without breaking apart, good cohesion*
2	*Little shrinkage mould not filled evenly, air bubbles*	*good*	*Cylindric test piece is rather soft and breaks easily when torn off from brick*
3	*Little shrinkage*	*good*	*Cylindric test piece is rather soft and breaks easily when torn off from brick*
4	*Little shrinkage*	*good*	*Cylindric test piece is rather soft and breaks easily when torn off from brick*
5	*Little shrinkage*	*good*	*Can be torn off from the adobe surface without breaking apart, good cohesion or less adhesion*

Table 3: Tests for injectability and workability

Grouting	***Injection cannula Ø=1,2mm***	***Injection tube Ø=3mm, length=15 cm***	**Flowability on vertical brick surface**	***Evaluation of workability***
Grouting 1	*Good when extra water is added*	*Good when 1 VP little extra water is added*	Pasty, not flowable, without dilution	*After adding some more water good injecionability, i.e. working behaviour. For cannula more water is needed, for tube only a bit*
Grouting 2	*impossible*	*Possible when water added, but blocks quickly*	Pasty, not flowable, without dilution	*Bad workability, needed dilution with water for use through cannula, without dilution grouting is too viscous and doesn't spread and adhere well.*
Grouting 3	*blocks easily*	*Blocks easily*	Liquid, "heavy" flowing down the vertical brick	Liquid, flowing down the vertical brick surface, feels "heavy".
Grouting 4	*Impossible even after warming up and adding water*	*Possible after warming up, but blocks easily*	Needed warming up to be fluid and was still not properly injectable, blocks cannula	*Bad workability because of the need for warming up and need for high dilution with water to be used through the tube, blocks easily.*
Grouting 5	*Blocks quickly*	*Blocks easily*	Blocks the cannula, while injecting	*Bad workability, it is only injectable through tubes, but blocks easily*
Grouting 6	*impossible*	*impossible*	Little shrinkage	*The grouting is heavy and flowing down quickly on the test brick.*

Table 4: Evaluation of a void model

Evaluation	***Grouting1***	***Grouting2***	***Grouting3***	***Grouting 6***
Usage	*Good injectability, spreads well*	*Too high viscousity, not fluidly injectable through cannulae, too much pressure needed to press through the 4 mm cannula, because of poor fluidity the pressure within the void model increases, the two boards started a cracking sound/ noise*	*Good injectability, but less than Grouting 1, somehow blocked within the hole in the board*	*Highly fluid, flows down the void*
Evaluation of break	*as a stamp within the void, 1 x break of cohesion, 2 x ripped off plaster from the board*	*As a stamp within the void, breaks within the grouting mortar, cohesion break*	*Two breaking phenomena: cohesion break in the plaster and mixed cohesion/adhesion break without damage of plaster*	*Where grouting got stowed and by this it bridged the gap, there is a cohesion break in the plaster*

▲Fig. 62: Testing flow-ability of Grouting 1 on left, Grouting 3 on the right

◄Fig. 63 (top): Testing for shrinkage while drying, all formulas had good results here

◄Fig. 64: Evaluation of cylindric test samples.

1 2 3 6

6 3 2 1

Fig. 65: Void model opened after one week of drying, grouting recipes 1, 2, 3 and 6 labelled on top.

Summary of Tests

The shrinking in the cylindric test model was little to very little for all groutings and all of them had a similar adhesion to an adobe brick surface. The working properties of the groutings varied quite a lot. The grouting modified with animal glue was very bad to inject. The syringe needed to be warmed and the cannulae as well as the small tube blocked quite fast. Grouting no 1 was best in tests for injectability and workability. The cohesion of the cylindric test piece of Grouting 1 was better than that of the others, except grouting 6, which also had good cohesion. On the results of the practical tests in which the different recipes were compared Grouting 1 was judged to be the most suitable. It can be used to fill or bridge bigger voids and diluted with more water it can be used with smaller cannulae to fill and re-adhere detachments.

Grouting the Voids

For wetting the voids it was first a mixture of water and alcohol (2:1) injected. Next grouting was injected, either with a syringe and small tube or a cannula (fig. 66, 68). During injection the surface of the plaster was held in position, so that it wouldn't bulge. After injection stamps were pressed on the surface to let the grouting dry in the voids under pressure. The stamps were wood sticks or sometimes an empty plastic bottle, which were cushioned with a piece of polyethylene foam enveloped into a piece of Evolon®-textile.[5] This was necessary otherwise the grouting would detach from the voids inner surface. This was an observation made during work. After at least one day of drying, the stamps could be removed. Where voids had big openings they were stuffed with filler material designed for filling the losses in the coarse coat (fig. 71, 72) first before grouting was injected after drying of the plaster.

Fig. 66 Injecting grouting through a small tube.

[5] Provided by the Company „Deffner & Johann GmbH", address: Muehlaeckerstr. 13, 97520 Roethlein, Germany, URL: http://www.deffner-johann.de.

Fig. 67
The detached edges of the big loss were grouted and pressed during drying with stamps-

▲Fig. 71, 72
Stamps hold the detached fine coat in position, while deep holes and reachable caverns get filled with coarse coat filler.

▲Fig. 68
Injecting grouting between detached fine coat and 2nd coarse coat layer with cannula.

▼Fig. 73, 74 (bottom)
Gathering sand-rich loam in a brick factory out of Ziyang, from this we sieved yellow sand, below sieving grey earth which from the riverbank, that had a fine homogeneous texture, which contained large amounts smaller 75 µm.

▼Fig. 69, 70 (bottom)
Gathering yellow loam below the road next to the village Wafangdian, below lain out for drying. Large stones were sort out by hand.

Preparation of Loam and Sand

For the grouting and filler recipes we used local building materials that needed to be prepared. We took grey clay and sand from the riverbank beneath the *beiwusheng huiguan* and yellow loam was taken from a slope of the smaller *jiang* river (fig. 69). Yellow sand we took from a brick factory out of Ziyang (fig. 73). The sands were sieved to the needed size. The loam was sort out, dried, crushed and larger particles than 75 µm were extracted by sieving (fig. 70, 74).

Fillings

For filling losses and deeper holes in the plaster different fillers were made. First a filler used for losses in the 1st and 2nd under coat was made, both were filled with the same mixture. The mixture was intended to have similar components and a similar composition to the original plasters determined by the quick analysis of the components done by Mrs. Fan Binbin in 2012 on site. She crushed a sample of the 1st and 2nd undercoat and had sieved the components.[6] For tests we also used loam and plant fibres, or better straw. In various compositions we observed shrinking during drying (fig. 75, 76). The mixtures with acceptable little shrinking and cracking had a proportion of clay and sand different from the original plaster. The amount of sand is higher and by this shrinking and cracking during drying is reduced. Shrinking would let the fillings detach from the losses flanks and therefore the mixture with a higher mount of sand was chosen to be suitable. The components were mixed with water and soaked for one day, before it was ready for use.

Recipe	***Loam***	***Sand***	***Straw***
Filler for undercoat	*10 VP (2 pts yellow loam: 1 parts grey loam)*	*3 VP yellow sand (<2 mm)*	*6 VP*

The fine coat filler was modified in three mixtures with different sized sand, to fill small, medium and larger losses in the fine coat. It consists of light grey coloured loam, yellow sand, cotton fibres, slaked lime and water. Loam and sand were soaked with water. Then small portions could be taken from the readily soaked mixture to get mixed with lime and fibres. The cotton fibres were pulled apart until they became fluffy and were spread onto the surface of the filler in the plaster mixing bowl. We used much less lime than analysis showed the original fine coat plaster contains, because in a test with a fragment of the fine coat, it fell apart when soaked it in water. We didn't want to create a filler that is harder than the old fine coat. The lime increased the viscosity of the filler and made it better workable and less doughy, it could be easier smoothened.

Before applying the fine coat filler, a slurry was applied to the loss, which made the filler better attach. Very small cracks, losses or open edges from dented surface were filled only with the slurry. The slurry was made from the fine coat filler mixture without fibres. The colour of the fine coat filler and hereby also the colour of the slurry, was adjusted in tests with different amounts of yellow and grey loam. The colour of the fine filler should fit as good as possible into the surface colour of the painted panels' background. By this, smaller fillings can already be reintegrated and wouldn't need retouching (fig. 77, 78).

Recipe	***Kaolin***	***Yellow Loam***	***Sand***	***Water***	***Lime***	***Cotton Fibres***
Filler for fine Coat, fine	*2 VP*	*1 VP*	*1 VP sand <0,4 mm*	*0,75 VP*	*0,2 VP*	*Finely pulled, amount to cover surface of mixing bowl*
Filler for fine e Coat, coarse	*2 VP*	*1 VP*	*1 VP sand <1 mm*	*0,75 VP*	*0,2 VP*	*Finely pulled, amount to cover surface of mixing bowl*

[6] See Final Report Part 1, p. 105.

Fig. 75, 76▼
Testing shrinkage of plaster fillers for coarse coat and fine coat.

Fig. 77
Pingfeng xi, detail of panel 3 b, paint layer loss and damaged fine coat.

Fig. 78
Pingfeng xi, detail of panel 3 b, losses in the fine coat filled.

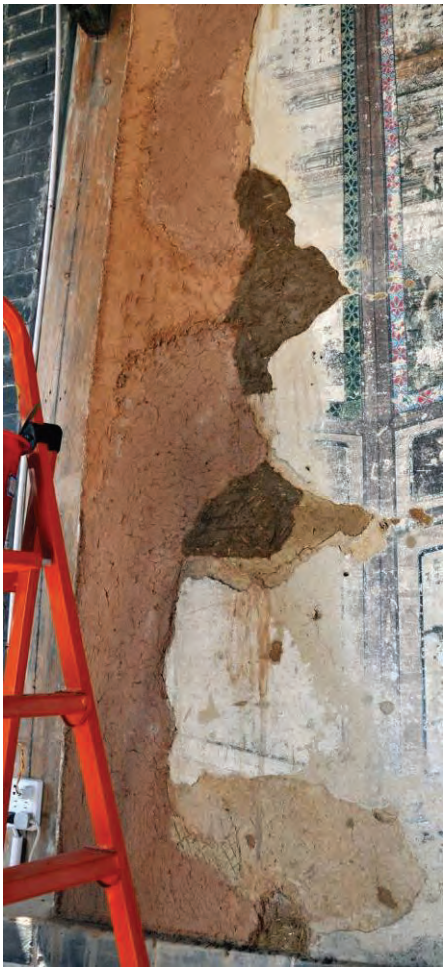


Fig. 79, 80 ▲
In the area of the big loss there are two different reddish repair mortars present. In little places there is the original surface of the 2nd coarse coat remained. For example in an oval shaped form on the bottom
The fillings up to the 2nd coarse coat level were made with the filler designed for losses in the coarse coat- The surface was roughened up with a criss-cross pattern, so that the fine coat would interlock with it.

Filling of the big loss

Along the edges of the big loss on the left of *pingfeng xi* the fine coat was detached from the coarse coat layers almost across the whole height of the wall. The detached parts were grouted and pressed into position during drying with a stamp, which was made from a piece of expanded polystyrene foam, enveloped into a piece of Evolon® mat pressed towards the wall by a wooden stick or sometimes also simply by an empty plastic bottle (fig. 67). In the area of the loss attempts had been made earlier to fill it up to the 2nd coarse coat level. Two different mortars were used for these repairs, both of a more reddish tint than the original plaster. Still in some places some more coarse coat mortar was needed to fill up to the 2nd coarse coat level entirely. The mixture used, is the same that had been designed to fill holes within the painting up to the coarse coat level, containing local earth (loam), straw and sand. The surface of the fillings was roughened up with a criss-cross pattern into the fresh mortar so that the fine coat would interlock with it (fig. 79, 80).

For the fine coat plaster we made a new mixture different from the fine filler, containing ore lime. Visual examination and also analysis showed, that the sand contained in the original fine coat as flat, rounded slate particles. This is just what the sand from the river right below the *beiwusheng huiguan* looks like. So we gathered the sand from the riverbank there. This sand made the plaster first unpleasantly grey, but when we washed out the fine greyish fractions of the sand it got better and together with yellow sand, yellow loam and lime a nice light yellowish colour resembling the original fine coat plaster was able to be made. (fig. 81).

The proportion of loam, lime and sand was chosen according to analysis results. We mixed in a similar amount to what our analysis showed, that the fine coat contains. This was around 50-50 -65 % quartz, around 10 – 30 % calcite and around 7-14 % clay minerals and others.[7] We sieved the riverbed sand to a maximum size of 3 mm and then washed it, to get out the fine greyish fraction. Then we took 5,5 parts grey river sand, 1 part yellow sand, 2,5 parts slaked lime and 1 part yellow loam (<75 µm). Finally 2 VP of finely pulled cotton fibres were added and thoroughly mixed. No extra water was added as the washed river sand already contained enough water. The plaster was good to spread and work and after drying only little cracks appeared. The plaster thickness applied varies from around 4 mm up to approximately 1 cm.

The application of the fine coat plaster was made with a trowel and carried out from bottom to top (fig. 82, 84). Along the edge of the original plaster a second person filled the crossing with a small spatula, to avoid soiling the historic surface. Bit by bit the coarse coat surface was carefully wetted before the plaster was applied, to not let the fresh plaster dry too fast and to improve the bond between coarse coat and fine coat (fig. 83

Yellow Sand	***Grey Riverbed Sand, washed***	***Lime***	***Yellow Loam***	***Cotton Fibres***
1 VP	*5,5 VP*	*2,5 VP*	*1 VP*	*2 VP*

[7] See also *Final Report Part 1*, p. 207.

Fig. 81
Tests with different kind of sands, to achieve the right colour for the big fine coat fill. The 2nd from left is the mixture with completely washed river sand and judged to fit best. This test wall is a later building in the *beiwusheng huiguan* in which the toilet is situated.

Fig. 82
The application of the fresh fine coat mortar carried out by a team of two. One filling the area and the second doing the crossing to the historic surface with a small spatula to avoid soiling.

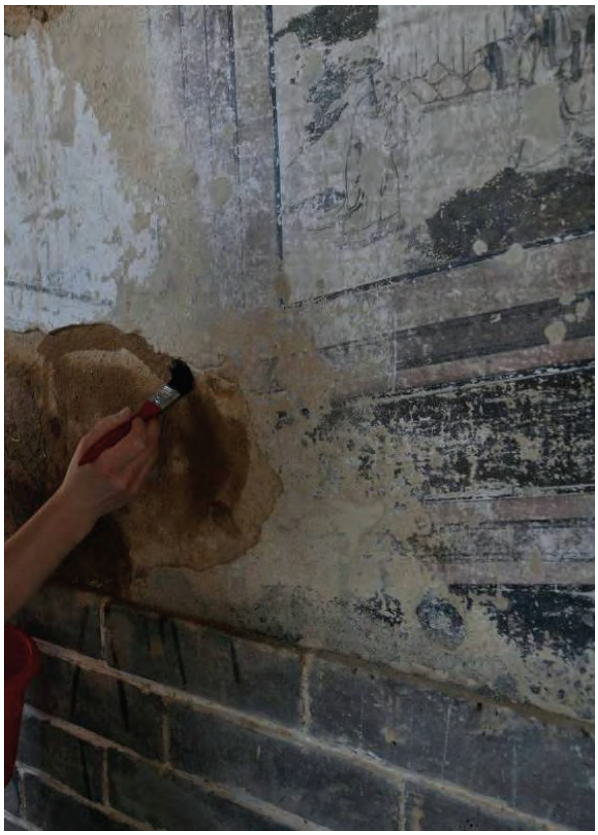


Fig. 83
The coarse coat surface was carefully wetted, before the fine coat plaster was applied. The paint layer of adjoining areas was not to get wet.

Fig. 84
Pingfeng xi, after drying of the applied fine coat in May 2012.

Fig. 85
Pingfeng xi, detail of panel 1 a. White priming material applied to the remains of original fine coat.

Priming Material

Along the edge of the big loss, the paint layer and also priming layer had in parts been washed off and the fine coat surface remained. In some parts also fine coat surface had been washed down, and the remaining fine coat material is rough and porous. These eroded areas were filled and smoothened with slurry made from the fine coat filler without fibres applied with a brush. Next this area was prepared with priming material (fig. 85).

The priming material is made *up of a 7 % rabbit hide glue* solution (+ 5% slaked lime) as a binder and of kaolin and yellow loam (9,6 : 0,4 VP) as fillers and also colouring components. 10 Parts of the glue solution were mixed with 8 parts of loam. The mixture was left to soak for one day and then some more water was added until the watery diluted condition as needed for a multi-layered application was reached.

The areas prepared with priming material were treated with a size of a 4 % rabbit skin glue to reduce absorbency and make retouching possible.

◀Fig. 86, Fig. 87 (below left)
Pingfeng xi, detail of a woman in panel 2b, before and after cleaning, consolidation and filling. The colour of the fine filler blends in with the surrounding colour and does not need to be retouched.

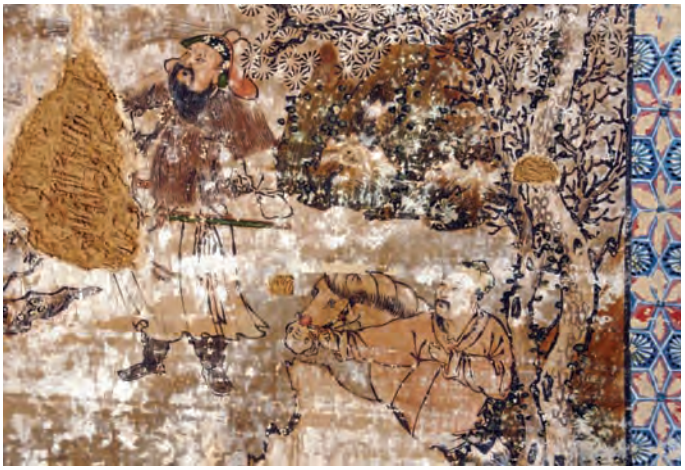


Fig. 88▲, Fig. 89 ▼
Pingfeng xi, panel 7 b and panel 4 b, The whitish discolouration found mainly within the panels with narrative scenes was decided not to be retouched. Parts of the painting layer are lost, injured or changed here, but parts are still present and would get covered. This damage is also found on the pendant mural *pingfeng dong* and was discussed within the Sino-German team and found to be acceptable as an aged condition.

Integrating Losses in the painting by retouching

At the end of the work stay in May 2013 all conservation works, such as consolidation, grouting and fillings up to the plaster level were finished. The big loss on the left hand side of the painting had also been filled with new plaster.

The losses in the paint layers had a mostly bright white appearance, because the priming layer was revealed, whereas losses that had been filled with fine coat filler looked light beige. Sometimes the colour of the fine coat fillings blended into the surrounding original colour very well and especially matched nicely with parts of the "background" within the panel scenes (fig.86, 87). However, in many other places the light or bright areas distracted from the depictions of the painting, especially in the lower half of the *pingfeng xi*, where many holes were filled within a dark surrounding (fig. 126). In this case, losses were reintegrated by retouching, so that they become less visible and the shape of losses does not dominate and hereby influence the readability anymore.

Concept, materials and technique

Before retouching was started, a concept had been defined regarding which losses should be retouched and which losses are to be left in its current condition. It was decided that retouching should only be carried out when paint layer is completely lost. These are areas that had been filled before and areas, where paint layer is lost but original priming layer or fine coat has remained, e.g. in areas of the brown framework or the slim black framings (fig.111). In areas of the narrative panels damages are present, where parts of the painting layer got lost or damaged. This damage can be observed along the horizontal flow of the brush with which the priming layer and maybe also the sizing layer was applied. It was decided that in this case no retouching should be carried out.

The background of the narrative panels was also subject to discussions since it shows white drops with slightly darker surroundings. We could not make sure, what exactly made the surface look white; however, the original painting materials could still all be present and could have just changed, due to a physical or chemical reaction. In these areas no retouching should be carried out as this would likely happen on original painting or drawing material and would then be not distinguishable anymore. As the surface is quite porous it would also not be reversible from the original surface anymore. It was decided that these damages should be regarded as something that belongs to the work's aged condition (fig. 88, 89).

Where it was possible to determine the original shape and colour, retouching was conducted to reconstruct it. The mural *pingfeng xi*, which depicts a folding screen, has a lot of architecture-like forms or shapes, which have a distinctive geometry. Losses within these clear shapes of two lines or areas of same colour can therefore be reconstructed. These areas are the black outer framing, the folding screens framework, but also objects that have a clear and distinct shape, for example vessels. Losses within repetitive patterns, like the black and red lattice-work in the top part and the blue and green flower or star borders could also be reconstructed by retouching (fig.90, 91).

The graffiti, which could not be taken off by cleaning should also be retouched since the Chinese colleagues wished them to be illegible. They can be covered with priming material and retouched to match the surrounding.

Fig. 90, Fig. 91▼
Pingfeng xi, panel 4 a, before and after restoration. Retouching reconstructed shape and colour of the framework, lattice-work and the repetitive pattern of the flower-and-star-border.

Retouching Paints

Sizing

To reduce the absorbency of the fillings to facilitate retouching, a sizing was applied to them. The sizing was made of sturgeon glue, soaked and melted in water and applied in a 3 % concentration to the fillings. Sturgeon glue sizing in a 1,5 % concentration was applied to the losses, where original paint layer is lost and retouching should be carried out. This was to reduce absorbency as well as to form a separating layer to the subsequent retouching, so that it would be easier to take it off again in the future, if this might be necessary.

In areas, where the paint layer is gone, but the original priming layer still present a 3 % concentration of sturgeon glue sizing was needed, the priming material was quite absorbent and would otherwise not have been able to retouch.

The retouching paints were made on site. We used rabbit skin as binder glue and stable pigments.[1] The rabbit skin glue was modified with a small amount of slaked lime, to make it more permanent against the climatic influence of humidity. For the binder the rabbit skin glue was soaked in water for at least four hours. Then it was warmed up to around 60 °C thus dissolved. Then a bit of slaked lime was added to the warmed glue and thoroughly shaken. The amount of lime was low, so as not make the animal glue flocculate. It was 5 % of slaked lime referring to the dry weight of the rabbit skin glue. For example, 100 ml of a 20 % rabbit skin glue solution was mixed with 1 g of slaked lime. We particularly wanted to use rabbit skin glue, because of its good elastic properties and purity. We imported it from Germany, because in China we only found unverified animal glue in shops for artistic supply. The slaked like came from the material stock of the Cooperation partner form the Research Center for Preservation of Cultural Heritage of Shaanxi Province. It could not be traced back, where it had been bought. It was a barrel, in which burnt lime stone pieces were soaked in water, but it was not finely dispersed yet. It needed to be disaggregated with a spatula and stirred to make it a usable paste. The amount of lime needed to not make the rabbit skin glue solution flocculate was determined in a test, with various concentrations and 5% lime of the dry weight of the glue turned out to be suitable.

Colour Hue	*Name of Pigment*	*Product Number of Providing Company Kremer Pigmente*
Yellow	*Cadmium Yellow No.6 Medium*	*No. : **21040***
Red	*Cadmium Red-orange No.1 Light* *Cadmium red No.1 Light*	*No. : **21100*** *No. : **21120***
Blue	*Cobalt Blue Turquoise Light* *Cobalt Blue Medium* *Cobalt Blue Dark*	*No. : **45750*** *No. : **45710*** *No. : **45700***
Black	*„Ivory Black Synthetic JU“ Bone Black (pigment in tinting quality of Ivory black)* *Furnace Black - Lamp Black*	*No. : **47200*** *No. : **47250***

Table: Pigments used for retouching paints.

[1] Glue and Pigments provided by the Company „Kremer Pigmente GmbH & Co. KG“, address: Hauptstr. 41 – 47, 88317 Aichstetten, Germany, URL: http://kremer-pigmente.de/en.

For making the paints the relation of dry weight of glue to pigment varied for each pigment group. It ranged from 8 percent for Cadmium pigments up to 14 percent for Furnace Black. The individual need for binder was determined for every pigment. By testing the resistance to rubbing over paint applied to a test board prepared with priming and sizing, The pigments used are listed in the table below. They all have a good light fastness and chemical stability and differ from the originally used pigments. This could be helpful in future analysis of painting materials, since the retouching is easily distinguishable from original materials. The pigments were ground together with the binder on a stone plate (fig. 92, 93, 94). The well-mixed paste could then be kept in the fridge for up to three weeks. And only small amounts were taken to the work site each day, to not prevent the paint stock in the fridge from rotting too fast.

The choice for this binder system should be shortly explained. We needed something with good working properties and stability in the uncontrolled climate on site. Especially in summer, when temperatures are often high there are also high rates of humidity. In the second work stay, in 2012, we started tests for retouching on site with watercolours. These watercolour paints, quite often used for retouching in cultural heritage were at all the time sticky and highly viscous.[2] This system might behave in the same way on the wall, so that we excluded this system from possible retouching media. We also thought about systems with synthetic binders, like *Paraloid B72* – a polymethymethacrylate Copolymer, *Mowilith 20* – a polyvinylacetate and *Laropal A 81*, an aldehyde resin. These would be are customized with stable pigments. They all would have to be processed with solvents and also be removed again with them. During cleaning tests for the stability of the paint layer we found, that there was no resistance against ethyl alcohol, acetone or ethyl acetate. The paint layer is also affected by water, but still a water-based system would best match the properties of the original painting materials. Animal glue is a binder which has also been used in the original painting and matched the character of the mural best. This binder might degenerate when aging, but to prevent this it was modified with lime. Unlike the synthetic binders animal glue paint will not influence the water vapour transmission negatively and fit well to the originally used materials.
For future projects the choice of pigments would be varied, as the cadmium pigments can become harmful to people and environment, especially when they get burnt and cobalt pigments shouldn’t contaminate soil or waters. These two pigment groups would not be chosen again.

[2] The watercolour paints were SCHMINCKE HORADAM® AQUARELL, paints in pans with highly lightstable pigments.

Fig. 92
Mixing of synthetic ivory Black pigment with rabbit skin glue on a stone plate.

Fig. 93, 94
Making of a paint with cadmium red pigment.

◄Fig. 95
pingfeng xi, panel 5d after restoration. The tratteggio retouching, which were visible at a close range are invisible from a distance, see also the photo before.

Fig. 96, 97
pingfeng xi, detail of panel 5d before restoration and after restoration. From a close range the mainly vertical lines of the tratteggio retouching is easy distinguishable from the original painting. Only the slim black panel filling frame (here the inner frame) was retouched using lines following the direction of the frame, i.e. also horizontal or sloping lines. From a distance fillings and losses are well integrated (fig. 95)

Retouching Technique

The technique of retouching chosen was „Tratteggio“. By this, losses were reintegrated with small vertical lines of 3–5 mm long. Using two to three layers of different colours, the losses are not recognisable as damaged anymore seen from a distance (fig. 95). The colour and shape match the surrounding painting, only at close range the structure of lines is perceptible and makes the retouching distinguishable from the old painting (fig. 96, 97). One exception was made for the retouching of the slim black panel filling frames. It turned out to be more suitable to use lines parallel to the frames' outlines. First we tried doing also consistently vertical lines, but the retouching orthogonally to the frame resulted in an uneven contour and only being able to paint one line across the width of the frame created a too well-ordered pattern.

Retouching of reconstructible areas

Reconstructible areas like the black framing, the folding screen's framework and geometric or distinctly shaped forms were reconstructed using tratteggio technique. The retouching was always carried out matching the surrounding colour of the loss. By this, the aged condition of the mural was not refreshed (fig. 107, 108).

The integrating by inpainting made the losses nearly invisible, depending on the distance of the viewer from it, and restored the mural's harmonic appearance (fig. 109, 110).

Losses, which had neither a geometric form nor a repetitive pattern, were considered not reconstructible and integrated with a neutral hue (e.g. hands, faces, etc.). A neutral hue was applied to the loss using tratteggio technique, so that the loss would disappear and not create a clear shape. For instance, the leaves of a tree were not reconstructed as they were neither a repetitive pattern nor a clear geometric shape (fig. 111, 112).

Graffiti

Graffiti done with ink, which could not be taken off without damage to the painting were covered with priming material made of kaolin and rabbit skin glue. They were furthermore reintegrated by retouching using a colour similar to the surroundings (fig. 113, 114, 115, 116). In one place someone had tried to take off the graffiti mechanically. By this the original surface below the ink and he surrounding was damaged. The damaged area with remains of graffiti was then treated like the others, by covering it with kaolin priming and retouching it with tratteggio (fig. 117, 118)

Limits to retouching technique

Small-sized losses −Acqua Sporca

There are also limits to this retouching technique and concept. Areas, which are too small to be retouched with 3 – 5 mm lines, such as losses in the black drawings of the narrative panels, cannot be retouched (fig. 121, 122, 123). It is possible to connect some of the lines but due to the small size tratteggio retouching would not be distinguishable from the original painting anymore. Connecting the lines would mean not to meet international standards in conservation of cultural heritage, therefore, no action was undertaken to retouch these losses.

Small-sized losses and scratches within an area of dark paint were treated differently since they are distracting and disturb the overall appearance. „Acqua Sporca“, a wash that is made of pigments and water was applied to this type of losses and makes it look less bright and hereby less obvious but still recognisable as a loss. Losses within bright areas of paint layer were not shaded, as here it would not be recognisable anymore as an addition (fig. 119, 120).

Another difficulty was the treatment of losses, where the original depiction could be assumed but not determined, for example a loss which was located where a head and a face has been before. Without retouching, the loss would distract too much and be competitive to the

painting. So the attempt was made to retouch the loss in a way that the shape of the woman's head can be conjectured, without reconstructing it in detail (fig. 124, 125 136, 137).

Limits to retouching concept

At the bottom of the mural *pingfeng* xi, the e-panels are severely damaged. There are only little remains of paint that give evidence of the design, which could be seen here before. The remains found belong to a bright yellow rounded ornament which was painted on top of the dark brown background (fig.98). Mostly the yellow pigment is lost and only the remaining whitish binder allows tracing the ornament. This trace looks like the yellow ornament, which is still present on the folding screen in the main hall (*zheng dian*), declared as *pingfeng bei* (fig. 99). At *pingfeng xi* the dark brown background of the e-panels looks like the colour of the background of the c-panels. The only difference is, that in the c-panels the space for the figure was left blank when the dark brown background colour was applied. In the e-panels the brown background colour was applied to the whole area and afterwards the yellow ornament was painted on top of it. At a closer look to the dark brown background colour of the pingfeng xi's e-panels there is a 2nd ornament (in chinese named *yun leiwen*) of an angular shape visible. This ornament is black and hardly visible within the dark brown background. It is located beneath the yellow ornament and in UV-Light the black ornament has a yellowish fluorescence (fig. 100, 101). This ornament is also present and well preserved in the e-panels of *pingfeng dong* (fig. 102). In some e-panels, especially in 8 e the flaking off paint layer occurred in the same place where the *yun leiwen* ornament was present (fig. 103). Because of this damage the *yun leiwen* ornament is well recognizable. The *yun leiwen* ornament was most likely already covered with the yellow ornament during the making of the murals. Either the *yun leiwen* ornament has turned black or the ornament could be overpainted as a change of the concept at an early stage. It is unlikely that it is a later addition because the background colour looks the same as in the c-panels. The yellow ornament is also present on *pingfeng bei* and there it is no later change, but the original and only design. These are the facts and now the question of how to deal with these badly damaged areas. After having integrated all bigger sized losses with retouching, either reconstructing colour and shape or in a neutral colour when it was impossible to reconstruct the drawing.

However, not enough material has remained to reconstruct this yellow ornament with retouching. Reconstructing the older, but better visible *yun leiwen* ornament would be wrong. The only possibility would be to integrate the losses into the brown background. The idea was, that the contrast of the dark brown paint layer remains get reduced and by this means the remains of the yellow ornament or the whitish traces of his ornament would become better visible. We were aware, that the situation created by integrating only into the background colour without an ornament would also create a synthetic condition on the e-panels. Not showing a bright ornament but integrating the losses into the background colour was still regarded to be the suitable way to treat these areas. Otherwise these areas would be the only places that looked fragmentary on this wall and also more fragmentary compared to the other murals' condition. So we started retouching these areas in a slightly lighter tone than the true background colour (fig. 104, 105). After a while we had a new discussion on the already mentioned synthetic, dark areas that we created with the missing necessary bright ornament giving the right contrast. It it was unsatisfactory to the team and conjointly decided to stop and leave these areas without reintegration. Only the slim black panel filling frames should still get reconstructed by retouching. The retouching, which had already been carried out

Fig. 98
Pingfeng xi, panel 5 *e*, traces of the yellow ornament on a dark brown background colour.

Fig. 99
Pingfeng bei, panel 1 *e*, the yellow ornament on a black background colour is much better preserved here.

Fig. 100
Pingfeng xi, panel 3 e, white fragments of yellow ornament on dark brown, the geometric ornament is black in the dark brown layer.

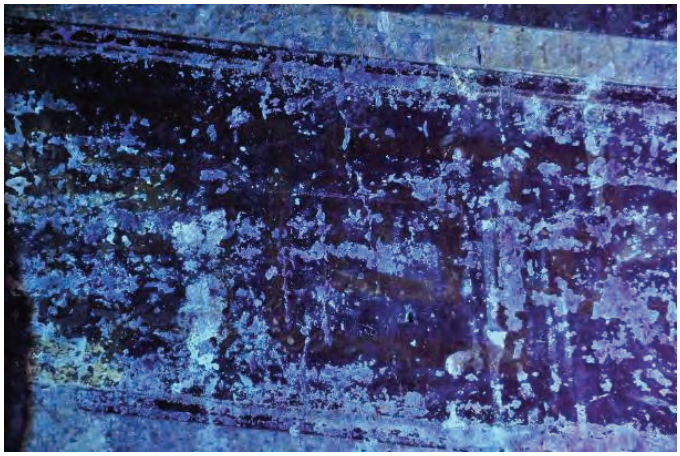
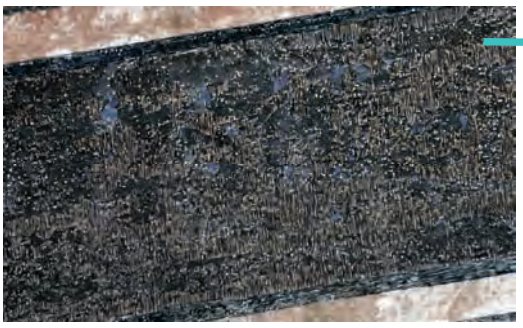


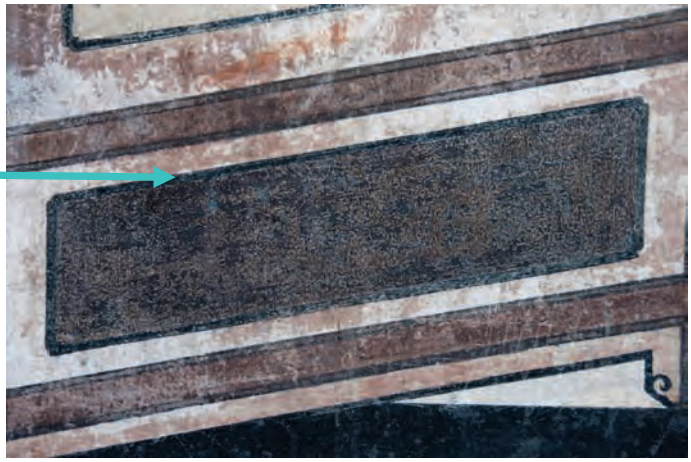
Fig. 101
Pingfeng xi, panel 3 e under UV light the geometric black ornament gets a yellowish fluorescence.

Fig. 102
Pingfeng dong, panel 6 e: *yunleiwen* ornament in pale blue with brown background

Fig. 103
Pingfeng xi, panel 8 e, losses follow the geometric ornament

Fig. 104
Pingfeng xi, panel 8 e, losses integrated into the background colour with tratteggio.





▲Fig. 105
Pingfeng xi, panel 8 e, detail of the retouched areal with remains of whitish binder from he yellow ornament.

Fig. 106
Pingfeng xi, panel 8 e, after reducing the retouching with a cotton swab and water. .

should get reduced by cleaning (fig. 106). The losses of paint layer in the other e-panels should stay without retouching. Only fillings within the damaged e-panels get integrated into the damaged layer by retouching. This might be deviating from the concept of reintegration, but there was no satisfactory solution for treating these areas, so they stayed fragmentary (fig. 109, 110).

Reconstruction of a lost Part of the Folding Screen

The big loss on the left hand side of the mural disturbed the painting very much, as the repetitive pattern of the framework of the eight-winged folding screen was interrupted by it (fig. 126). A reconstruction of the missing part would give back structure and balance to the motif, but would have to be carried out in an unobtrusive way, for example, by keeping it in a lighter colour than the original painting. For this already the priming layer to apply as the "white background" layer applied to the new plaster should be lighter than the old painting's white background. Before applying the priming a sizing was applied onto the new fine coat. The sizing was made from a 4 % rabbit skin glue solution, to which slaked lime was added. It was the same amount of slaked lime as used when making the retouching paints: 5 % of the dry weight of rabbit skin glue. The priming layer is made up of a 7 % rabbit hide glue solution (+ 5% slaked lime) as a binder and of kaolin and yellow loam (9,6 : 0,4 VP) as fillers and also as colouring components. 10 Parts of the 6 % animal glue solution were mixed with 8 parts of filler. The mixture was left to soak and then some water was added to achieve the watery diluted condition which was needed for a multi-layered application. In total 3 layers were applied. After the first layer and after the last one, the priming was smoothened with sanding paper. On top of the priming layer a sizing of a 3 % rabbit skin glue solution was applied (+5% slaked lime).

The paints for the reconstruction of the missing part were made from a mixture of rabbit hide glue, egg yolk and pigment. The pigments were ground with 5 % rabbit skin glue by weight relation of the pigment. When the mixing was finished 50% of the weight of the pigment eggyolk was added. For example 10 g of pigment were ground and mixed on the stoneplate with 10 g of a 5 % glue solution and 5 g eggyolk was added. From these pastes of paint the highly diluted washes needed to paint the new part were produced by adding water After having finished the mixing more binder was added. To 80ml of a wash 20 ml of a 20 % glue solution was added and another 10 g of eggyolk. By this the pigment to binder relation can not be tracked exactly. It was a practical approach to attain the goal of getting the right dilution, to a paint or wash with the right properties to get the desirable thin character. The ability to bind was controlled by applying the paint to test boards and also to a test wall in an unused storage room in a building which is destined to be demolished. In a similar way, as in the original creating process, the missing part was outlined: with using chalk lines. After having completed the sketch, the contour lines were started to be drawn. A much thinner black paint was used than the painters had originally used to get a tone that is a like the worn black paint layer and even a bit less intense (fig. 127). Then the paints for the framework and the panel frames were applied in a translucent, wash-like way. The irregular structure of it, which is typical for the painting, occurred automatically when painting the missing part of the framework onto the new support (fig. 131). The adjoining areas to the old plaster, where paint layer and priming layer had been lost were prepared with priming layer as well, and integrated using tratteggio technique. Only on the new plaster, the lost form was reconstructed by painting it (fig. 128−135). Finally, the patterns in the top region and the flower borders were reconstructed with thin paint, with wash-like appearance. The middle and bottom panels, named c and e-panels, were filled with a brown middle tone, because figurative scenes were not considered reconstructible. Finally the mural had a well-balanced, harmonious appearance while preserving the signs of its aged condition (fig. 139).

Fig. 107, 108 ▼
Pingfeng xi, panel 8c, during filling and after restoration. The retouching is always matching the surrounding colour of the loss. By this, the aged condition of the mural was not refreshed.

Fig. 109, 110▼
Pingfeng xi, bottom right quarter, after fillings carried out on the photo on the top, retouching done below.

Fig. 111, 112 ▼
Pingfeng xi, panel 2d, during filling and after restoration. Losses, which had neither a geometric form, nor a repetitive pattern, were considered not reconstructible and integrated with a neutral hue. A neutral hue was applied to the loss using trattegio technique, so that the loss would disappear and not create a clear shape. For instance, the leaves of a tree were not reconstructed as they were neither a repetitive pattern nor a clear geometric shape.

Fig. 113, 114 (right)
Pingfeng xi, panel 7d, before and after covering and retouching the graffiti.

◄ Fig. 115, 116 (below)
The graffiti were covered with priming material made of kaolin and rabbit skin glue and after this they were integrated into the surrounding colour by retouching.

▲Fig. 117, 118
pingfeng xi, detail of panel 5d. Inadequate try by somebody to remove graffiti (left). The remains were covered with priming material and made to match the damaged surrounding by retouching.

▼Fig. 119, 120
pingfeng xi, panel 4d, before and after application of “aqua sporca”, this calms the bright uneasy look caused by small with trattetggio unretouchable losses.

Fig. 121 , 122
Limits of the retouching technique: The miniature-like drawing lines here in panel 8d (left) could not be connected or reconstructed with tratteggio techniques and therefore stayed fragmentary. This also applies to the damaged contour drawing of the bird in panel 2b (right). The tratteggio lines would not be distinguishable from the original drawing and therefore not meet international standards in conservation of cultural heritage.

▼Fig. 123
Pingfeng xi, panel 6b, the lines forming the waves were not retouched in a reconstructing way. The size is too small, so that the tratteggio lines would not be distinguishable from the original drawing anymore.

▲Fig. 124, 125 (left)
Pingfeng xi, panel 2d, limits to retouching, the head of the young lady cannot be reconstructed with retouching, as it would mean to invent the shape, but without retouching the loss distracts much. An integration with retouching needed to be done, without too much invention.

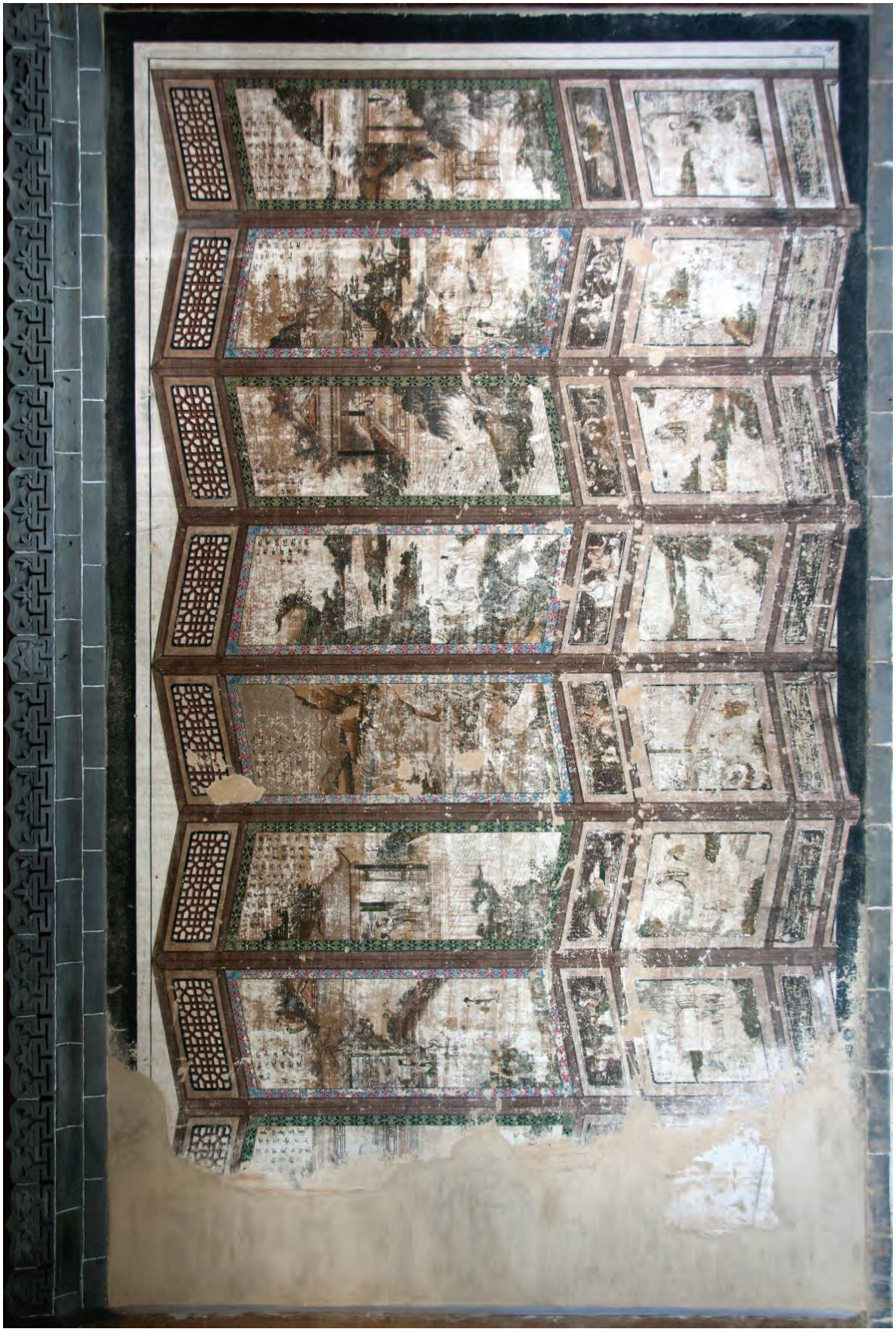


Fig. 126
State of *Pingfeng xi* at the end of the work stay in May 2013, with all conservation works, fillings and plaster addition on the left hand side of the mural carried out-

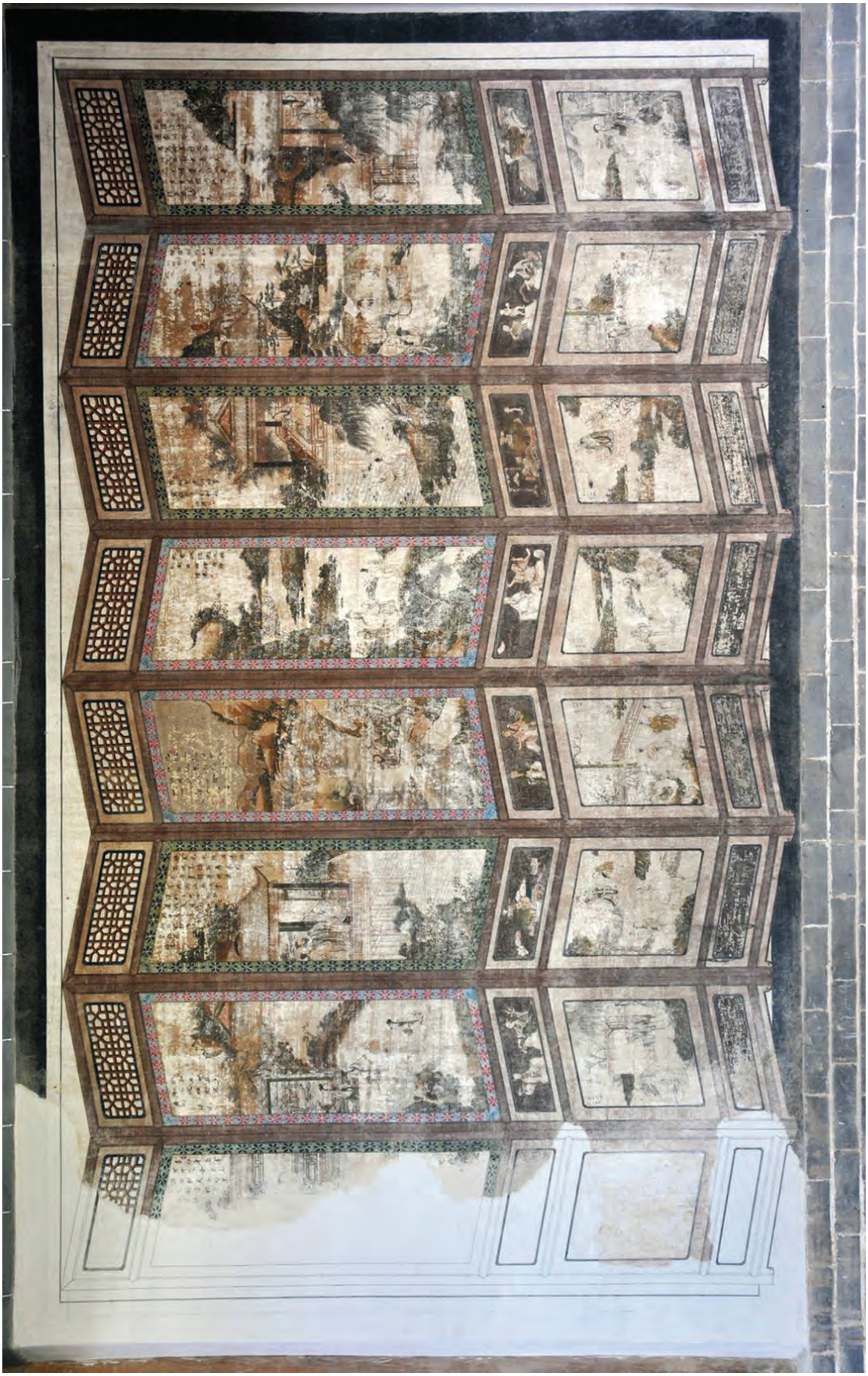


Fig. 127
Pingfeng xi during the reconstruction process in. Retouching on the original plaster is finished. The new plaster has been coated with priming layer and outlines are drawn.

Fig. 128
Pingfeng xi, a-panel before restoration.

Fig. 129
Pingfeng xi, a-panel with new plaster addition, priming layer and contour lines. The damaged old part has been retouched in tratteggio technique.

Fig. 130, 131
Pingfeng xi, b-panel, the reconstruction on the new part has been carried out in a lighter colour than the original painting, the painting colours were thin, watery washes. Everywhere, where old fine coat still existed, tratteggio retouching was used to integrate and reconstruct lost parts. Only on new plaster the missing parts were painted new.

Fig. 132
Pingfeng xi, panel 1d, before restoration.

Fig. 133
Pingfeng xi, panel 1d, after restoration.

Fig. 134
Pingfeng xi, panel 2e, after restoration.

Fig. 135
Pingfeng xi, panel 2e, after restoration.

Fig. 136, 137
Pingfeng xi, panel 7d, the head of the man cannot be reconstructed by retouching, as it would invent something new, but without retouching the loss distracts much. An integration by retouching was attempted without too much invention.

Fig. 138
At the border between old and new plaster, the technique changes from tratteggio to watery applied paint..

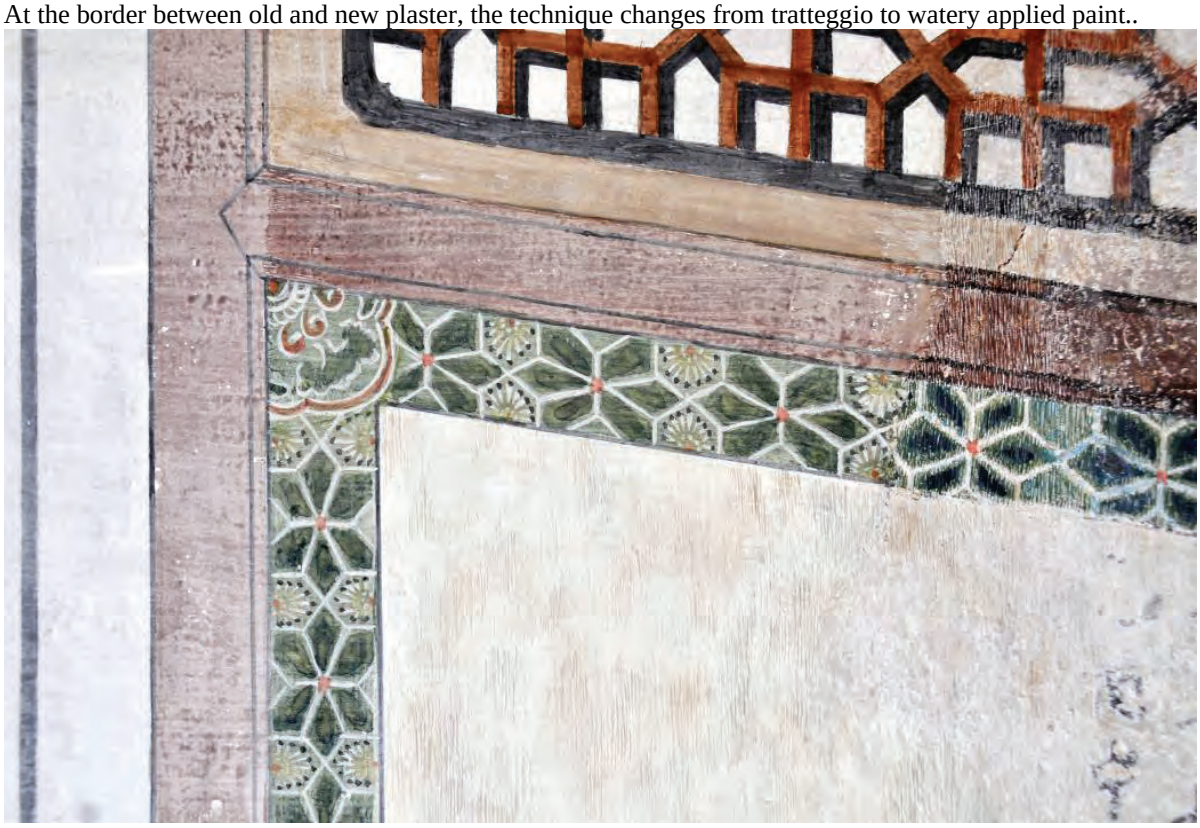
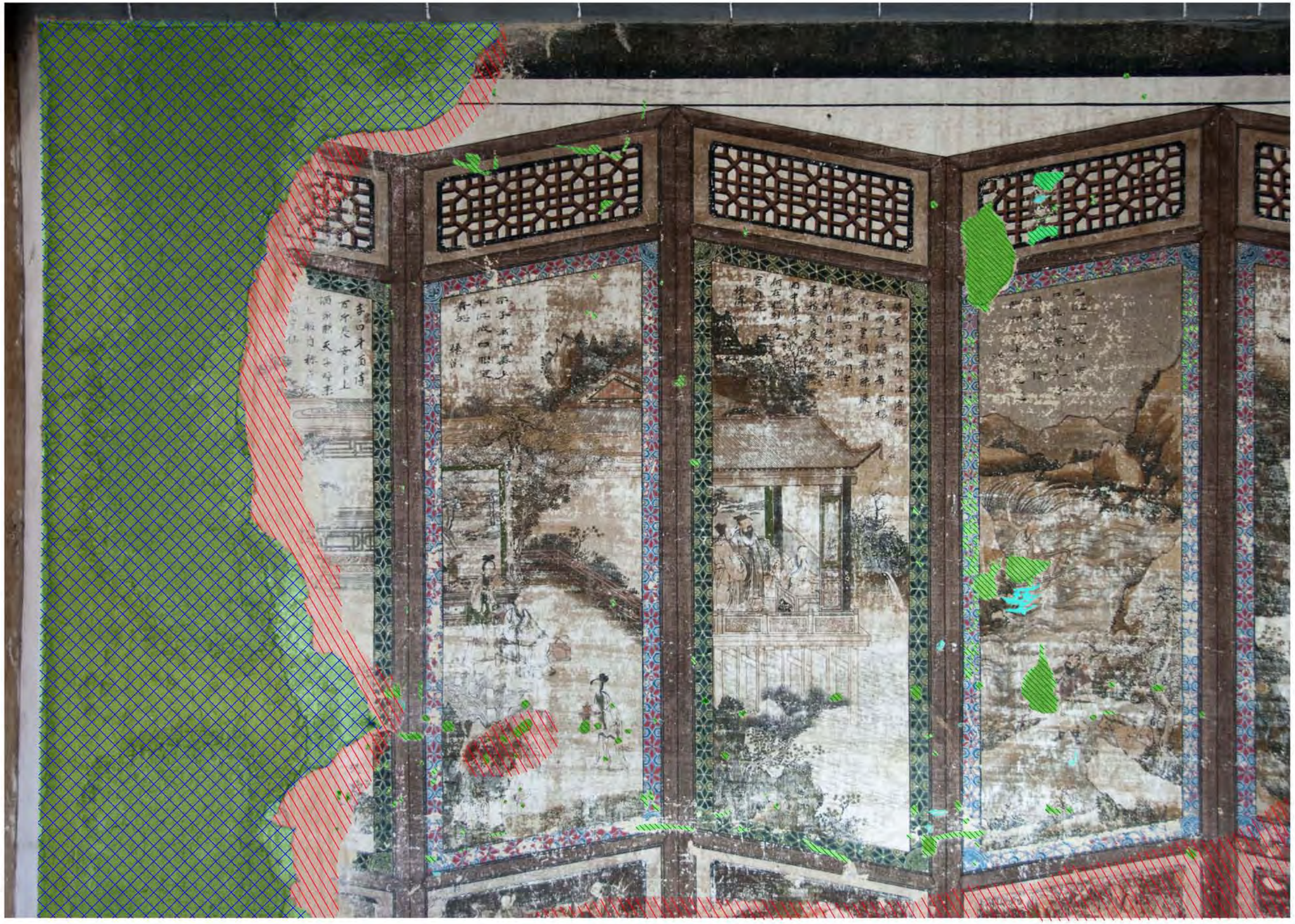


Fig. 139
Pingfeng xi in the final state, after all conservation and reconstruction works had been finished at the end of august 2013.

Mapping of Treatments of *pingfeng xi*

BEIWUSHENG HUIGUAN | PINGFENG XI (top left quarter) - Mapping of Treatments - May 2013



1.77m

2.49m

ConservationTreatments

- Grouted cavern
- Filling
- Filling on an edg
- New Plaster, Reconstruction

BEIWUSHENG HUIGUAN | PINGFENG XI (top right quarter) - Mapping of Treatments - May 2013

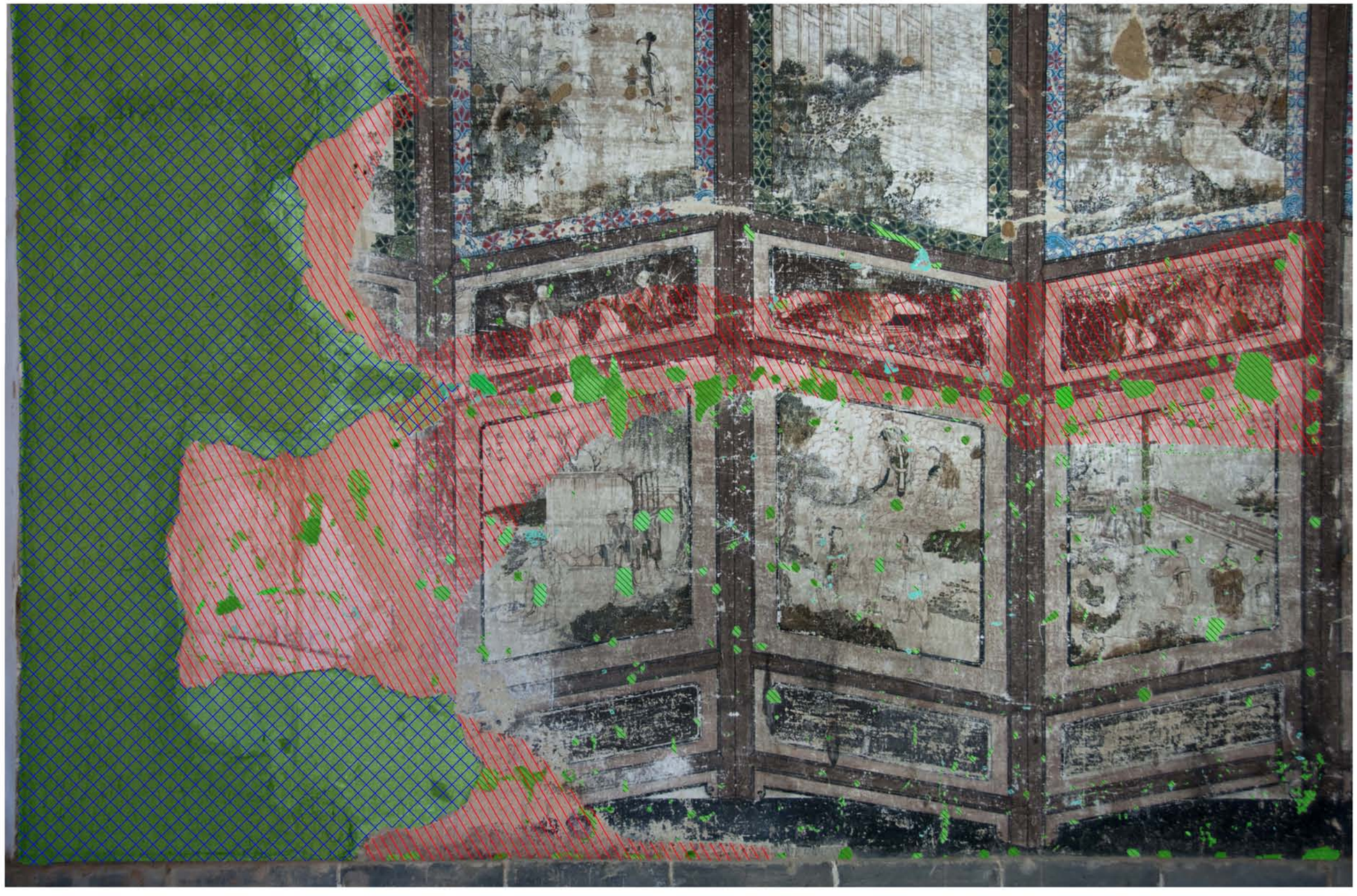
1.68m

2.51m

Conservation Treatments

- Grouted Cavern
- Filling
- Filled Edge

BEIWUSHENG HUIGUAN | PINGFENG XI (lower left quarter) - Mapping of Treatments - May 2013



Conservation Treatments

- Grouted Cavern
- Filling
- Filled Edge
- New Plaster, Reconstruction

1.55m

2.37m

BEIWUSHENG HUIGUAN | PINGFENG XI (lower right quarter) - Mapping of Treatments - May 2013

Conservation Treatments

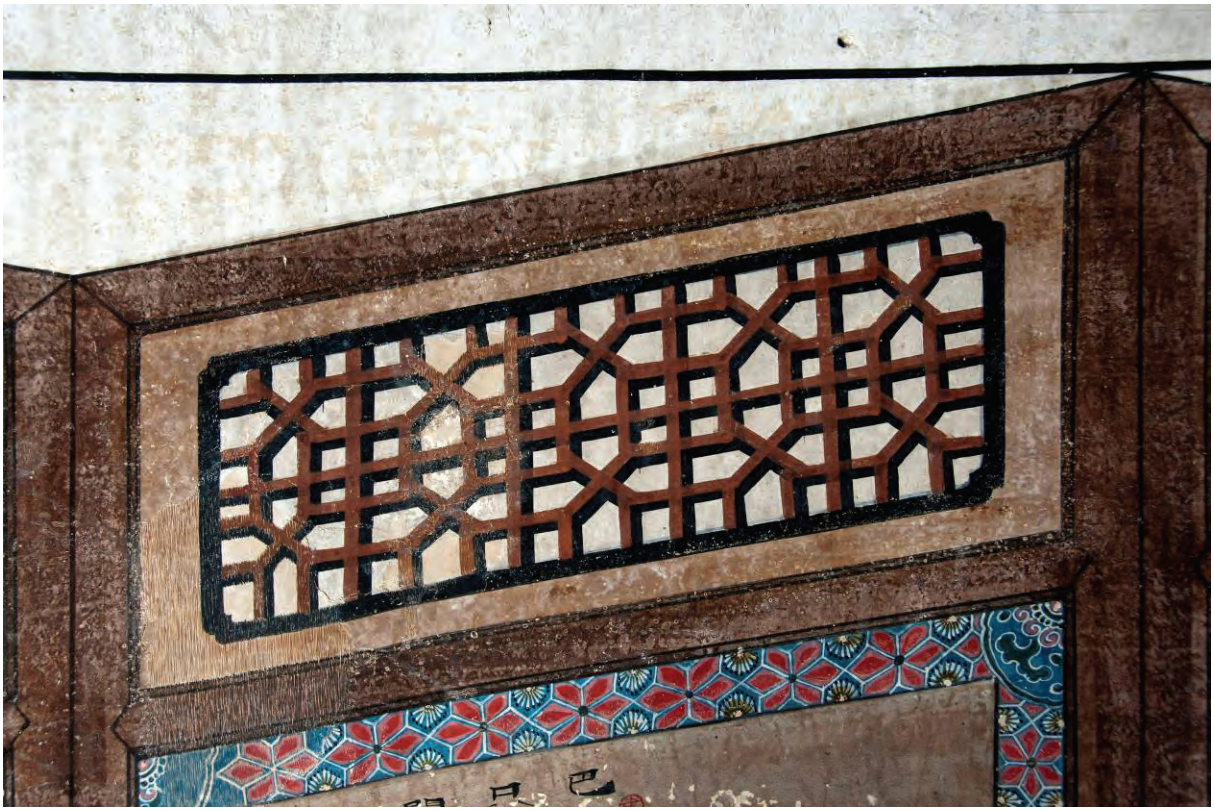
- Grouted cavern
- Filling
- Filling on an ed

SYSTEMATIC PHOTOGRAPHS OF MURAL *PINGFENG XI* AFTER CONSERVATION AND RESTORATION

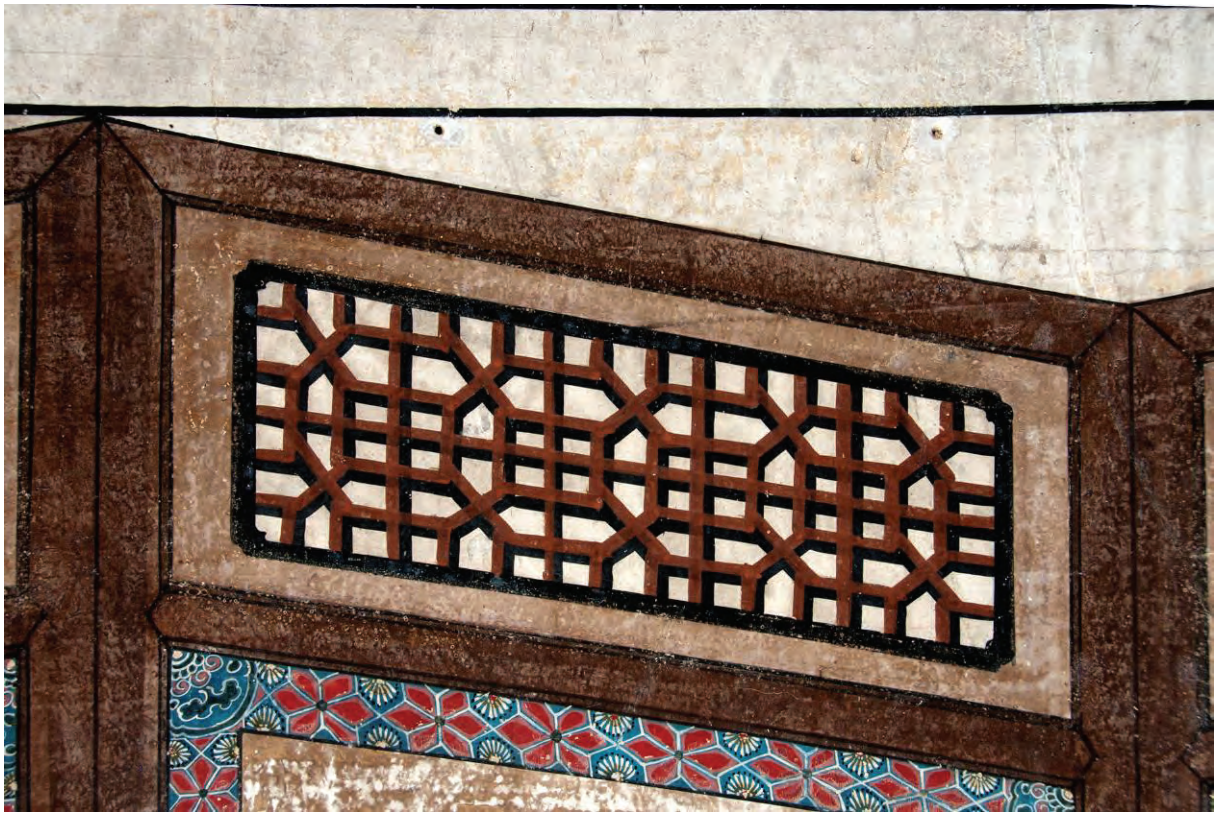
Panel 1a

Panel 3a

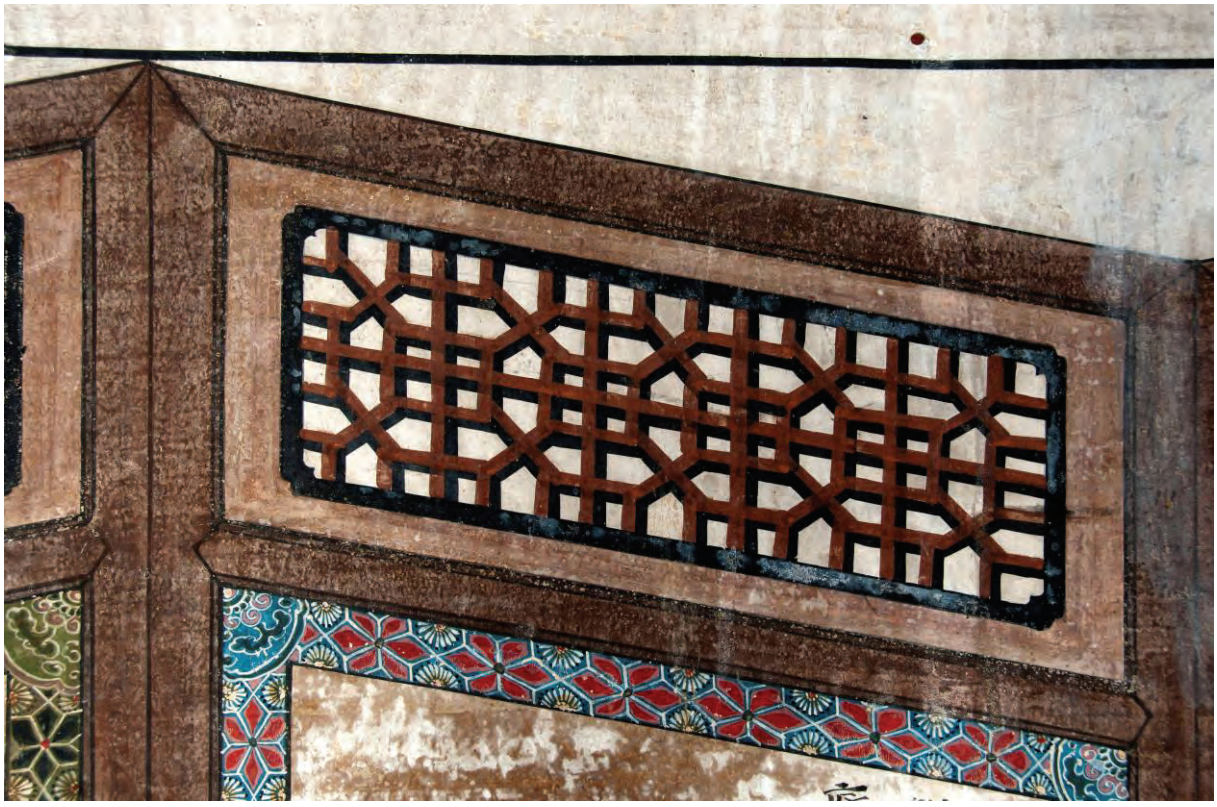
Panel 2a



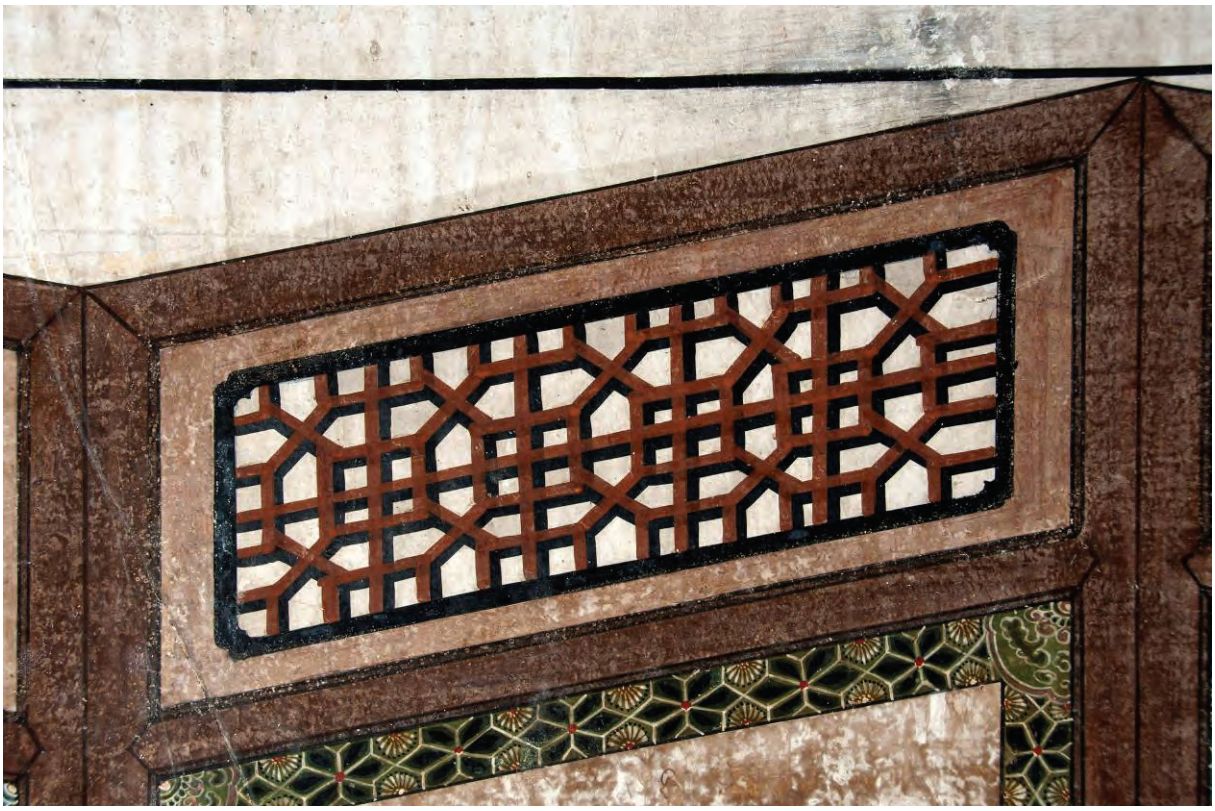
Panel 4a



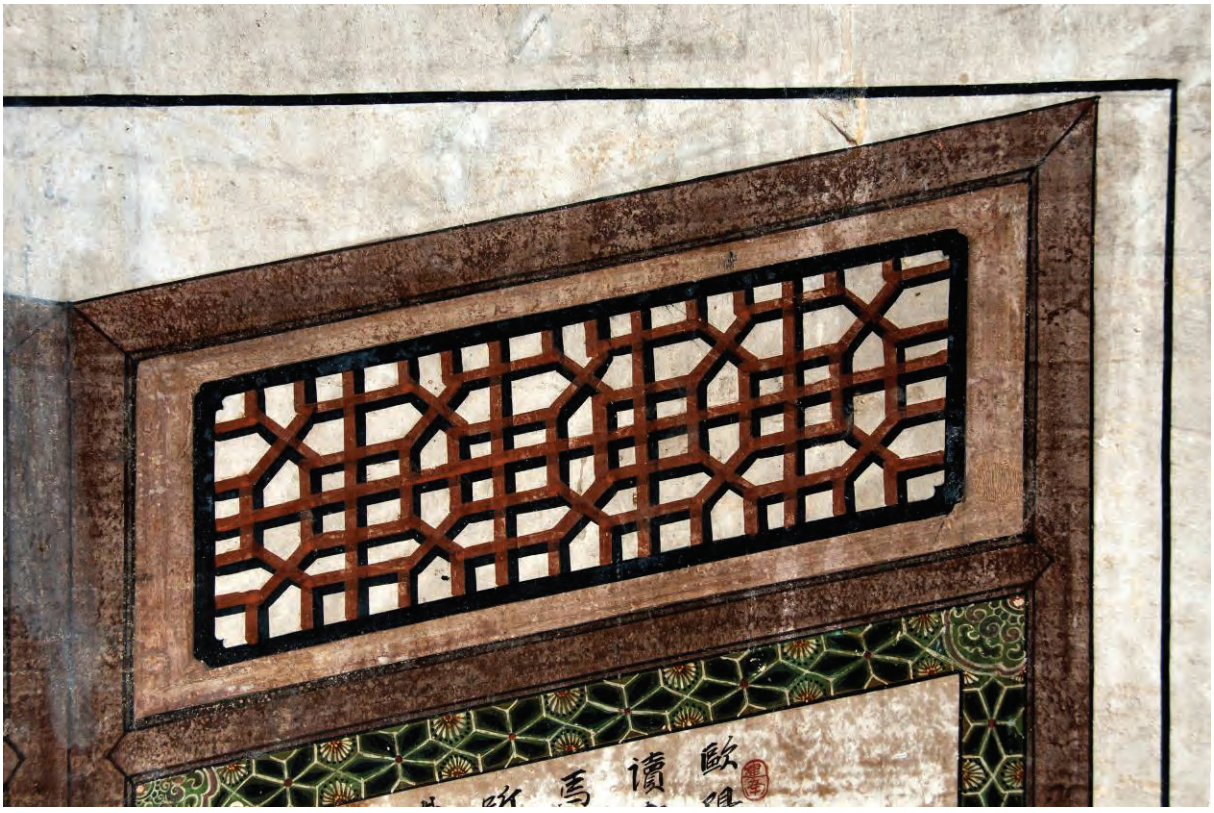
Panel 5a



Panel 7a



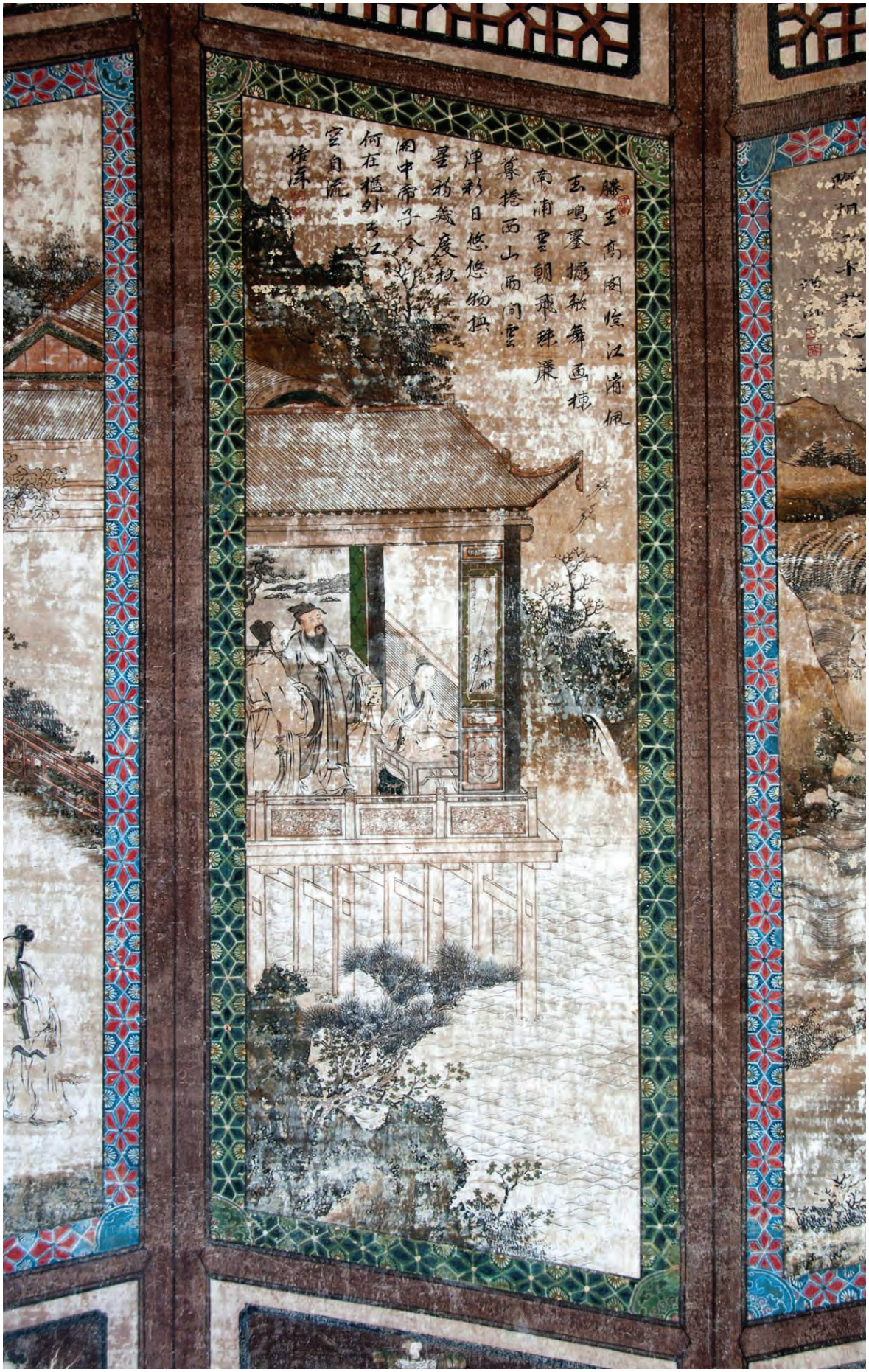
Panel 6a



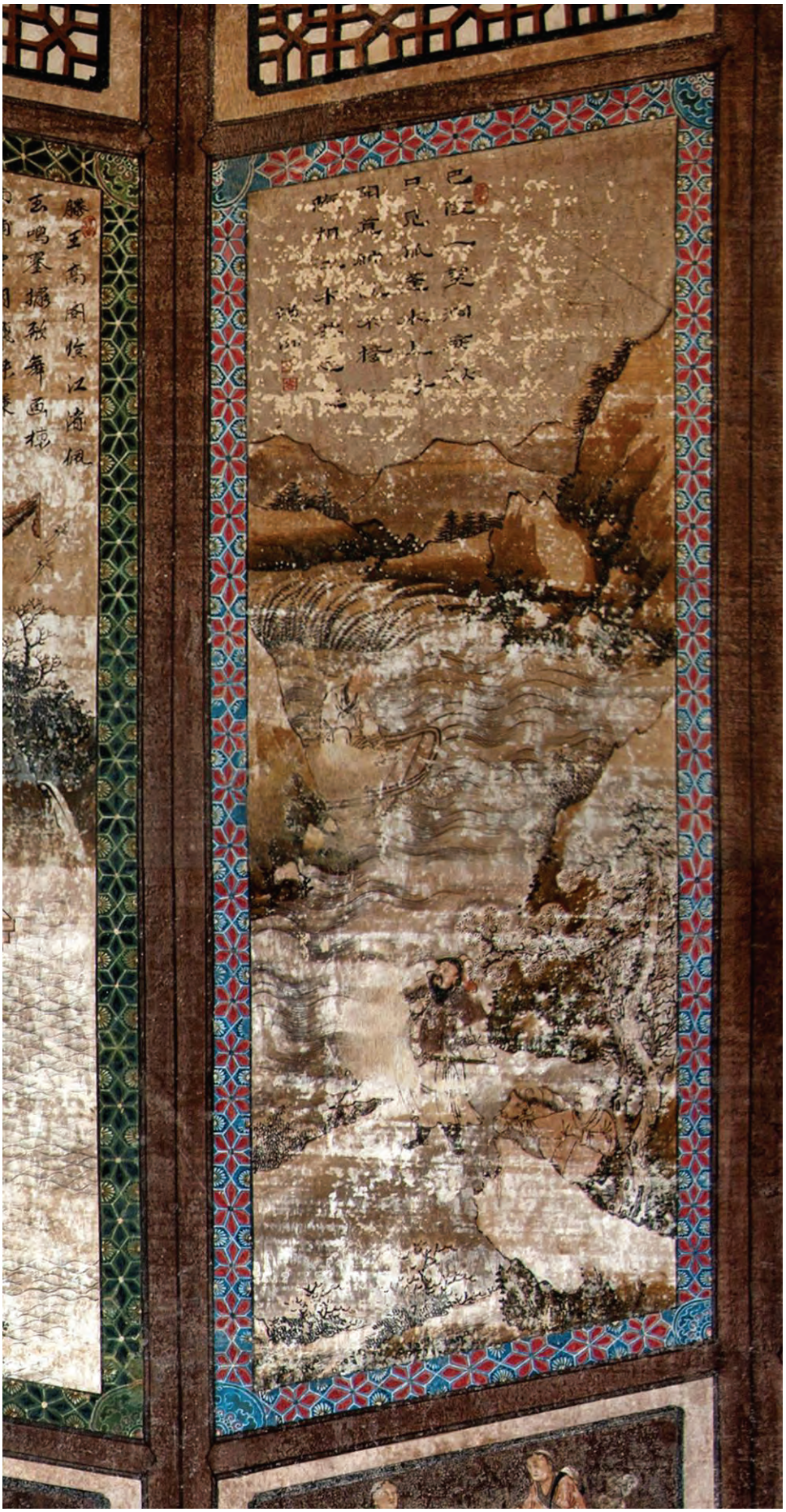
Panel 8a

Panel 1b

Panel 2b



Panel 3b



Panel 4b

Panel 5b

Panel 6b

Panel 7b

Panel 8b

Panel 1c

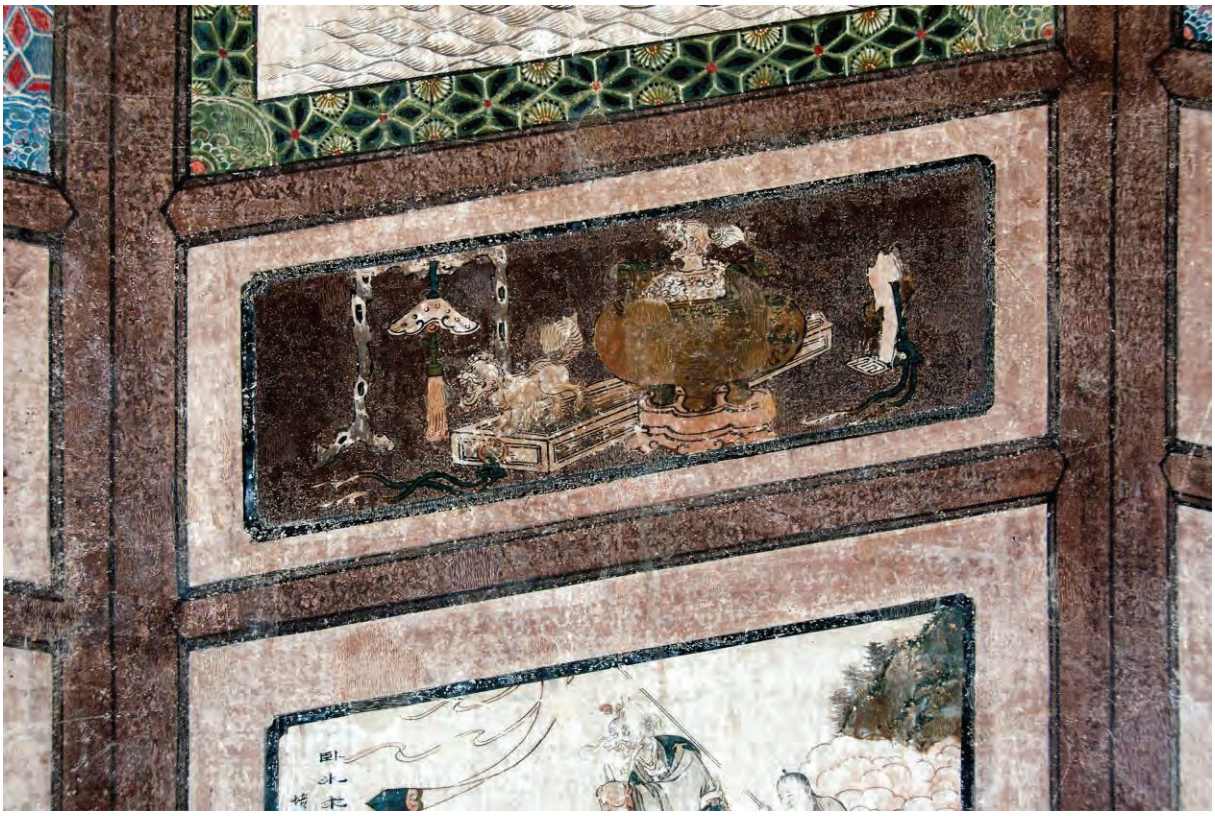
Panel 3c

Panel 2c

Panel 4c

Panel 5c

Panel 7c



Panel 6c

Panel 8c

Panel 1d

Panel 2d

Panel 3d

Panel 4d

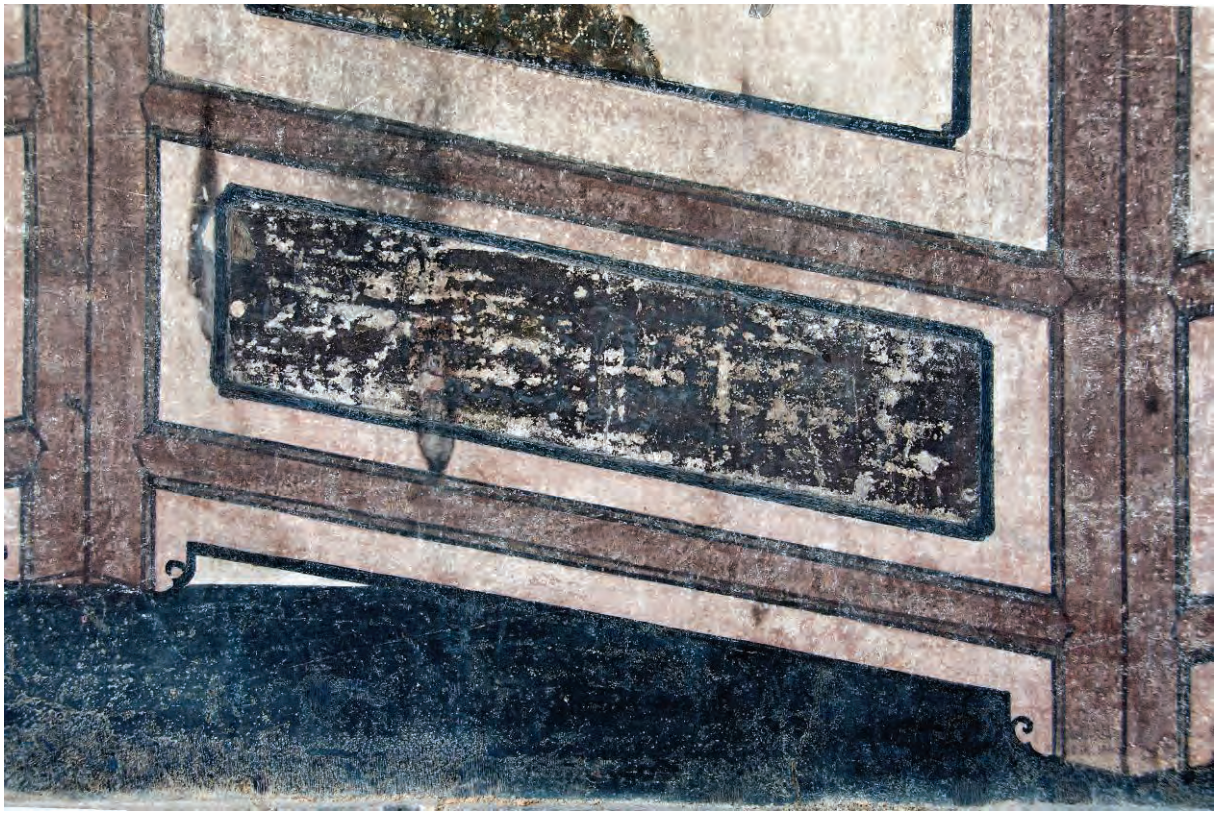
Panel 5d

Panel 6d

Panel 7d

Panel 8d

Panel 1e



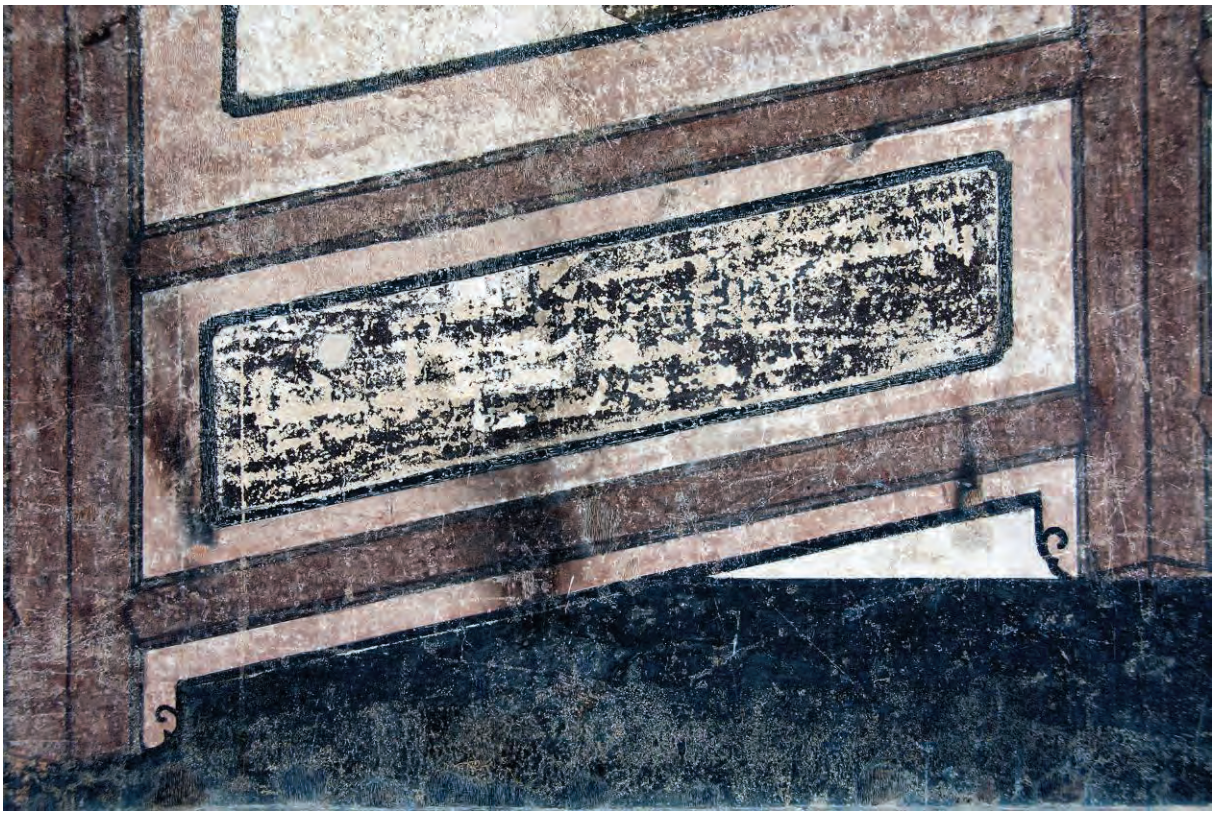
Panel 3e

Panel 2e

Panel 4e

Panel 5e

Panel 7e



Panel 6e

Panel 8e

LIST OF MATERIALS USED

Product's Name	***Usage***	***Provider***
"Akapad® soft", dry-cleaning sponge	Used for cleaning the mural *pingfeng xi*	„Deffner & Johann GmbH" Address: Muehlaeckerstr. 13, 97520 Roethlein, Germany URL: http://www.deffner-johann.de.
"Wallmaster", dry-cleaning sponge	Tested for cleaning the mural *pingfeng xi*	„Deffner & Johann GmbH"
Evolon® CR	Textile used during paint layer consolidation and grouting	„Deffner & Johann GmbH"
Cadmium Yellow No.6 Medium, No. 21040; Cadmium Red-orange No.1 Light No. 21100; Cadmium red No.1 Light, No. 21120; Cobalt Blue Turquoise Light, No. 45750; Cobalt Blue Medium, No. 45710; Cobalt Blue Dark, No. 45700; „Ivory Black Synthetic JU" Bone Black (pigment in tinting quality of Ivory black) No. 47200; Furnace Black - Lamp Black, No. 47250	Used to make retouching paint	"Kremer Pigmente GmbH & Co. KG" Address: Hauptstr. 41 – 47, 88317 Aichstetten, Germany URL: http://kremer-pigmente.de/en.
Fu Nori, japanese algae glue	Used as a component for paint layer consolidant	"Kremer Pigmente GmbH & Co. KG"
Rabbit skin glue, cubes	Used to make retouching paint, priming material and in parts for sizing	"Kremer Pigmente GmbH & Co. KG"
Technical gelatine powder	Tested for paint layer consolidation	"Kremer Pigmente GmbH & Co. KG"
Slaked lime	Used to modify rabbit skin glue and for fine coat filler, slaked lime used for the large plaster repair on left of *pingfeng xi* was provided from the stock of the Cooperation Partner	"Kremer Pigmente GmbH & Co. KG" and Cooperation Partner
Scotchlite™ K 1, hollow glass microspheres	Glass Bubbles to make grouting	"Kremer Pigmente GmbH & Co. KG"
Pumice Powder 000, fine	Tested to make grouting	"Kremer Pigmente GmbH & Co. KG"
Tylose 300 MH	Used to make grouting	"Kremer Pigmente GmbH & Co. KG"
SCHMINCKE HORADAM® AQUARELL, watercolour paints in pans with highly lightfast pigments	Tested for use for retouching paints	"Schachinger" Shop's address: Josephspitalstraße 6 80331 Muenchen Germany
Sturgeon glue in pellets	Used as a component for paint layer consolidant and partially for sizing	„Stoerleim-Manufaktur Eva Przybylo" Address In der Helle 21, 59929 Brilon, Germany URL: http://www.stoerleim-manufaktur.de.
Ethanol	Used for wetting voids before grouting	Provided by cooperation partner
Cotton fibres	Used to make fine coat filler and repair plaster	Provided by cooperation partner
Building materials such as loam, sand and straw	Used for grouts, fillers and repair plasters	Local resources described in text.