

Conservation treatment for the plasters and wall paintings of Tuna el-Gebel's tomb houses

Alexandra Winkels, 30.11.2018

1. [Introduction](#)

The tomb houses of the Petosiris Necropolis contain a large variety of plasters wall paintings. Partly openly exposed and weathered these original materials of the archaeological adobe architecture and its architectural surfaces developed extensive damages and deterioration phenomena.¹ In their overcome condition they are in urgent need for conservation to prevent further material loss. To treat the occurring damages a sustainable emergency conservation concept was developed on site since 2009 by Prof. Dr. Dipl.-Rest. Nicole Riedl-Siedow and diploma-conservator Alexandra Winkels according to international conservation standards.² It was based on the results of previous interventions³, and detailed new investigations including visual-phenomenological examination of the original materials and their technology as well as a condition assessment and damage analysis on site (Fig. 1) and natural scientific analysis on selected plaster-, paint layer- and pigment samples.⁴ The collected investigation results built an important basis for the understanding of the ancient plasters and wall paintings just as for the development of adequate conservation materials and methods. The diversity of original materials used in combination with each other includes clay plasters, lime-based plasters or white washes as well as pigments applied in different wall painting techniques. This required individual material choices and procedures for their treatment resulting in an extensive recipe collection.

This chapter summarizes the implemented emergency conservation measures since 2009 and shows representative examples of on-site work. To see which conservation steps were carried out in the individual tomb houses click on the icons installed for each house in the map of the Necropolis to be found on the project's website front page under the link "conservation".

1 See chapter "Existing wall paintings and their condition" on website.

2 See e.g.: ICOMOS ed. 2004a, ICOMOS ed.: Charta von Venedig 1964, S. 37-39; in: Monuments and Sites 1. International Charters for Conservation and Restoration. Second Edition, München 2004. And ICOMOS ed. 2004b, ICOMOS ed.: Charta von Lausanne. Charta für den Schutz und die Pflege des archäologischen Erbes (1990), S. 83-90; in: Monuments and Sites 1. International Charters for Conservation and Restoration. Second Edition, München 2004. Or Stanley-Price 2004: Conservation and management of archaeological sites, Volumes 6, Numbers 3 & 4, London 2004 or Torracca 2009: Lectures on Materials Science for Architectural Conservation; Getty Conservation Institute, Los Angeles 2004.

3 Besides the measures excavator Sami Gabra undertook in the Necropolis between 1931 and 1952, further conservation was carried out by: Winkels 2010, A. Winkels: Konservierungsbericht der Grabungskampagne 2009. Dokumentation der durchgeführten Maßnahmen an Fundobjekten und der Konservierung der Grabstele des Hermokrates, GB 20, S. 1-28; unveröffentlichter Konservierungsbericht zur Grabungskampagne 2009. Lindner – Quast 2007, Olaf Lindner, Astrit Quast: Arbeitsreport, konservatorische und restauratorische Maßnahmen an den antiken polychromen Wandfassungen, Nekropole Tuna el-Gebel (Mittelägypten), Oktober 2007, S. 1-5; unveröffentlichter Konservierungsbericht zur Grabungskampagne 2007. Schindler 2007, Claudia Schindler: Restaurierung, S. 115-122; in: Lembke et al. 2007. Rogal 2005, Robert Rogal: Tuna el Gebel. The "Egyptian House" Murals. Conservation Project. First Season in 2005.

4 Winkels and Riedl 2015, A. Winkels – N. Riedl: Entwicklung von Putz- und Maltechnik in der Petosiris-Nekropole von Tuna el-Gebel. Erste Untersuchungsergebnisse zu Akkulturationsprozessen in der Region Mittelägypten, in: K. Lembke – S. Prell (eds.) 2015, Die Petosiris-Nekropole von Tuna el-Gebel Vol. 1, Tuna el-Gebel 6 (Vaterstetten 2015) 260–303. For further information on the original materials, analytic procedures and results see chapter „technology“ on project website.



Fig. 1: Prof. Dr. Nicole Riedl-Siedow investigating plaster- and wall painting fragments with magnifying glasses in situ 2010. On the freely exposed architecture of GB 21 (M11/SS) and within the second room of tomb house GB 33 (M20/SE) on the upper storey paintings.

2. [The choice of conservation materials](#)

An important part of the conservation concept development was the composition of suitable conservation materials and methods. Only high-quality conservation materials and refined recipes were tested and used for the necessary treatments (Fig. 2-5)⁵. Their selection was based on the scientific analytic results ensuring a compatibility with the original plaster- and painting materials in terms of material characteristics as well as their physical-mechanical and chemical properties. The conservation materials were required to be water vapor permeable without forming surface films or seal the porous structures. They should provide a good aging stability in the hot arid Egyptian desert climate, as well as being consistent against insect infestation or microbiological growth. Accordingly, no acrylic resins such as Primal or Paraloid or harder gypsum and cement mortars that can develop material immanent tensions should be used.

⁵ The necessary conservation products and tools had to be organized in large amounts, purchased within Egypt or if not available imported from Germany to make sure nothing was missing on site.



Fig. 2, 3: Empirical testing of conservation materials and recipes for the development i.e. of suitable conservation mortars and injection grouts.

Fig. 4, 5: Practicing with conservation materials on defined test areas and individual material set up on conservation site.

Instead a combination of sensitive organic cellulose ethers⁶ and mineral silica binders⁷ were chosen for the conservation of the adobe masonry surfaces, clay- and lime plasters as well as their wall paintings. These materials fulfil the named criteria, are partly reversible as for example the cellulose bound conservation mortars and allow further conservation treatment of the original materials if necessary (Fig. 2-5).

Another essential advantage is that these materials can be applied with a reduced water content, the cellulose-ethers even purely being solved in alcohol. This was especially important for the water sensitive clay-based building materials and paint layers. As these react directly to contact with water by swelling or can even be dissolved when getting too wet.

While the mentioned material decisions and developed methods were generally applicable for all assessed tomb houses, the implementation of methods was partly varied according to the need of each individual object.

The manifold conservation recipes and methods used are summarised in detail at the end of the next chapter (see table 1).

⁶ For material information see e.g.: Klucel: <https://www.kremer-pigmente.com/media/pdf/63700-63712e.pdf>, accessed 28.11.2018; Feller and Wilt 1993, Robert L. Feller, Myron Wilt: Evaluation of Cellulose Ethers for Conservation, research in Conservation 3/1990, Getty Conservation Institute, second reprint 1993. Horie 2010: Materials for Conservation, organic consolidants, adhesives and coatings, p.207, London 2010.

⁷ Syton X30 is a water-based silica sol dispersion on the basis of SiO₂: <https://www.kremer-pigmente.com/media/pdf/31430e.pdf>, accessed 28.11.2018. Ludox PX30 mentioned in table 1 is the successor product of Syton X30 and was used in the later field school campaigns.

3. Implemented wall painting- and architectural conservation on site

After this detailed preparation, wall painting- and architectural conservation was conducted at the Petosiris Necropolis in four practical field schools between 2012 and 2018. With united woman- and manpower each year a group of Egyptian and German conservation students and conservators carried out the emergency conservation at several selected tomb houses. These were chosen according to the first assessment done by Prof. Dr. Nicole Riedl-Siedow and the writer.

Though preserved in fragments, the existing plasters and wall paintings within the Necropolis are still extensive. - And equally the need for conservation. Due to the limited time on site however, conservation work always had to be prioritised and focused on the most endangered areas of painted plasters. -Therefore, the term “emergency conservation” is used. The conducted measures mainly included conservation treatment essential for the prevention of further material loss. For example, structural mud brick- and plaster consolidation, the injection of voids between masonry and plaster layers or the application of mortar renderings along fragile plaster edges (see table 1).

The field schools always started with a series of theoretical lectures on the investigation-, documentation- and conservation procedures to be implemented. After a session of “test conservations” on defined practice areas (Fig. 4), to familiarise with the materials and methods the working steps on site and objects were as follows:

- Photographic documentation of the areas to be conserved- “condition before treatment”.
- Manual and digital graphic documentation⁸ of preserved original plasters and wall paintings and occurring damage phenomena on printed photo plans of the objects (Fig.6).
- Implementation of emergency conservation treatment, mostly groups of 2-4 people worked at different tomb houses (Fig. 7-10).
- Graphic documentation of conservation measures.
- Photographic documentation of conserved areas – “condition after treatment”.
- Written documentation of conservation treatment.

Discussions and experience exchange during work was always welcome and much appreciated. To aid the active on-site conservation and the reproduction of conservation recipes (Fig. 11) a handout was produced including a table with the used conservation recipes along with the work procedure for each conservation step. The following table 1 is based on this handout. It lists and describes the conservation measures conducted in the tomb houses. The selected pictures show examples of on-site work and conservation treatment (Fig. 6-17). More treatment examples can be seen on the website-map of the necropolis under “conservation”. The information for the different tomb houses can be accessed via the pins on the map.

⁸ For more details see chapter “documentation” on website.

1. Structural consolidation of adobe brick masonry

Conservation recipe/ composition	Application/ procedure
<p>1 a) First step:</p> <ul style="list-style-type: none"> • 1% Klucel E⁹ → in Ethanol¹⁰ (89 %) and demineralised water (10 %) 	<ul style="list-style-type: none"> - Dry cleaning of the area with soft brushes and air blower. Afterwards application of Klucel with syringes and cannulas: - Application on whole bricks along the plaster edges, of bricks behind the plaster edges as far as reachable and of joint mortar. - Make sure that the surface is evenly soaked with the consolidant - Then leave to dry.
<p>Or 1a) First step: Pre-consolidation of mud brick masonry → for stronger destabilised areas:</p> <ul style="list-style-type: none"> • 2% Klucel E → in Ethanol (88 %) and demineralised water (10 %) 	<p>The joint mortar of the mud brick masonry often is more structurally destabilised also can be some brick sections. In this case a higher concentrated Klucel solution- 2% of Klucel E can be used for consolidation- for the joint mortar as well as for stronger destabilised mud bricks. Application with syringes and cannulas:</p> <ul style="list-style-type: none"> - The application method corresponds to 1a.
<p>1b) Second step:</p> <ul style="list-style-type: none"> • 20% Ludox PX 30 → in demineralised water (70%) with Ethanol (10%) <p>(The aqueous silica acid dispersion Ludox PX 30 contains a 30 % concentration of silica and a specific weight of 1200 g/litre.)</p>	<p>Application with syringes and cannulas (or if necessary with soft brushes)- after drying of Klucel E in first consolidation step (see 1a).</p> <ul style="list-style-type: none"> - Application on whole bricks along the plaster edges, of bricks behind the plaster edges as far as reachable and of joint mortar - Make sure that the surface is evenly soaked with the consolidant. - Then leave to dry. - When time is at stake, for a better work efficiency: In areas where rendering of plaster edges was carried out, the mud brick masonry and the rendering mortar can be consolidated together after the drying of the rendering mortar (see section 4). - Very clean working is necessary- the Ludox PX 30 cannot be removed after drying!

2. Structural stabilisation of masonry sections- mud brick and stone masonry

Conservation recipe/ composition	Application/ procedure
For Mudbrick masonry:	

⁹ The binders Klucel- or Tylose- in their initial form as white powder are weighed with a scale in weight percent: 1% = 1 g. The solvents like demineralised water or Ethanol, used to produce the conservation solutions are measured in ml. The percentage for the mixtures refers to a sum of 100% per solution.

¹⁰ Initially Isoporpanol was used as alcohol for this and other recipes as it has a slightly slower retention as Ethanol. As it was very difficult to order in good quality and higher

<p>2 a) Joint mortar to close open joints in mud brick masonry:</p> <p>Binder: 1 % Tylose 10.000 in demineralised water</p> <p>Filler: Bentonite + washed Desert Sand → 1: 4 (volume parts¹¹)</p> <p>Mixture Binder/ Filler: 1 : 3 (volume parts)</p>	<p>Application with spatulas on surfaces pre-consolidated with conservation material 1a/b (see section 1). It is not necessary to wet the surfaces before the Application of the mortar. The pre-moistening with Water must even be prevented as it causes a stronger Swelling of the original clay building materials.</p> <ul style="list-style-type: none"> - The mortar must be thoroughly pressed into the Joints without leaving air holes or cracks <p>A good connection to the aligning brick sides and Underlying void mortar should be guaranteed</p>
<p>Alternative (if no Bentonite available)</p> <p>Binder: 1 % Tylose 10.000 in demineralised water</p> <p>Filler: Clay + washed desert Sand → 1: 10 (volume parts)</p> <p>Mixture Binder/ Filler: 1 : 4,5 (volume parts)</p>	<p>Application with spatulas on surfaces pre-consolidated with conservation material 1a/b (see section 1). It is not necessary to wet the surfaces before the application of the mortar. The pre-moistening with water must even be prevented as it causes a stronger Swelling of the original clay building materials.</p> <ul style="list-style-type: none"> - The mortar must be thoroughly pressed into the joints without leaving air holes or cracks <p>A good connection to the aligning brick sides and underlying void mortar should be guaranteed</p>
<p>For mixed masonry with mud brick and stone:</p>	
<p>2 b) Bedding mortar/ joint mortar for the structural stabilisation and filling of holes within stone and mud brick masonry</p> <p>Mud brick dissolved in water used as a plastic mass in humid state mixed with washed desert sand</p> <p>Mixture: 2 : 1 (volume parts)</p> <p>Mud brick mass: Washed desert sand</p>	<p>Application with spatulas to set up mud brick fragments to close bigger holes within the mud brick masonry; in smaller cavities the mortar was used without additional brick fragments.</p> <ul style="list-style-type: none"> - Also addition of 1% Tylose 10000 / 30000 in water possible for better water retention within the mortar during drying- small tests required.
<p>2 c) Lime mortar for the structural stabilisation and filling of holes within mixed masonry (stone and mud brick)</p> <p>Binder: Slaked lime</p> <p>Filler: Washed desert sand</p> <p>Mixture: 1,5 : 3 (volume parts)</p> <p>Slaked lime : Washed desert sand</p>	<p>Partial build up and closing of holes in mixed masonry, consisting of stone masonry with worked stones and Field stones as well as mud brick masonry sections; Application with spatulas.</p> <p>The mortar was used not too wet as a fine plastic stable mass. If too wet shrinking cracks can develop. Before applying the lime mortar the surrounding surfaces should be moistened as well as stone fragments that are set in the mortar.</p> <p>In areas of mud brick masonry the wetting must be reduced to the minimum to prevent the dissolution of the adjacent mud bricks and clay mortar.</p>

¹¹ "Volume parts" were used as measurement unit in many recipes. In the following this unit is partly stated with the abbreviation "v.p."

3. Structural consolidation of very fragile plaster and plaster edges

Conservation recipe/ composition	Application/ procedure
<p>3 a) First step- clay and lime plaster</p> <ul style="list-style-type: none"> • 1% Klucel E → in Ethanol (89 %) and demineralised water (10 %) 	<ul style="list-style-type: none"> - Dry cleaning of the area with soft brushes and air blower. <p>Application of Klucel with syringes:</p> <ul style="list-style-type: none"> - Application of whole bricks along the plaster edges, of bricks behind the plaster edges as far as reachable and of joint mortar. - Make sure that the surface is evenly soaked with the consolidant. Then leave to dry.
<p>3 b) Second step- clay and lime plaster</p> <ul style="list-style-type: none"> • 10% Ludox PX 30 → in demin. water (80%) with Ethanol (10%) 	<p>Application with syringes - after drying of pre-consolidation (3a). Only in very fragile areas, where the consolidation with Klucel (3a) is not sufficient.</p> <ul style="list-style-type: none"> - Application of whole bricks along the plaster edges, of bricks behind the plaster edges as far as reachable and of joint mortar. - Make sure that the surface is evenly soaked with the consolidant. Then leave to dry. <p>Very clean working is necessary- the Ludox PX 30 cannot be removed after drying!</p>

4. Rendering mortar for lime plaster edges and small fillings within white plaster

Conservation recipe/ composition	Application/ procedure
<p>4a) First step- Rendering mortar</p> <p>Binder: 1 % Tylose 10.000 in demineralised water</p> <p>Filler: Marble powder : Sand → 1 : 3 (volume parts)</p> <p>Sand: Desert sand washed and dried Marble powder: 32 µm</p> <p>Mixture Binder/ Filler: 1 : 6 (volume parts)</p> <ul style="list-style-type: none"> • Or: Mixture Binder/ Filler: 1 : 5 (v. p.) → For outside areas, where mortar dries faster. <p>- Do not use too much binder, otherwise the mortar consistency is too fluid and the fine-grained marble powder accumulates on the mortar surface during application.</p>	<ul style="list-style-type: none"> - Dry cleaning of areas with soft brushes and air blower. <p>When producing the mortar:</p> <ul style="list-style-type: none"> - Filler: Mix first one part of the sand with the marble powder. Then add the sand part by part, while always mixing thoroughly before adding the next portion of sand. - Mixture Binder/ Filler: Mix first one part of the filler with the binder, then add the filler part by part, while always mixing thoroughly before adding the next portion of filler. <p>Application of mortar with spatulas on surfaces pre-consolidated with conservation material 1a or 1b (see section 1).</p> <ul style="list-style-type: none"> - Before the rendering mortar is applied it should be assured that the plaster edges are stable enough, possible other necessary conservation treatment of the paint layer and plaster might have to be carried out first in fragile areas before the rendering is possible. - The mortar must be thoroughly applied onto the plaster edges and the gaps behind these without leaving airholes or cracks between masonry and plaster.

	<ul style="list-style-type: none"> - A good connection to the aligning brick sides and underlying void mortar should be guaranteed. <p>Make sure to always cover the mortar material you do not use immediately- to prevent it from drying out.</p>
<p>4b) Second step- consolidation of rendering mortar (only in outside-areas)</p> <ul style="list-style-type: none"> • 20% Ludox PX 30 → in demin. water (70%) with Ethanol (10%) 	<p>Application with syringes - after drying of rendering mortar.</p> <ul style="list-style-type: none"> - Application of whole bricks along the plaster edges, of bricks behind the plaster edges as far as reachable and of joint mortar - Make sure that the surface is evenly soaked with the consolidant - Then leave to dry <p>Very clean working is necessary- the Ludox PX 30 cannot be removed after drying!</p>

5. Mortars for rendering clay plaster edges and small fillings within thin white plaster

Conservation recipe/ composition	Application/ procedure
<p>5a) First step- Rendering mortar</p> <p>Binder: 1 % Tylose 10.000 in demineralised water</p> <p>Filler: Clay + washed desert sand → 1: 10 (volume parts) → 1: 9 (volume parts) → 1: 8 (volume parts)</p> <ul style="list-style-type: none"> - The mixture of the filler should be chosen after the mortar colour of the original plaster. The higher the clay content/ less sand- the mortar colour gets more brownish and slightly darker. <p>Mixture- Binder/ Filler: 1 : 4,5 (volume parts)</p> <ul style="list-style-type: none"> - Do not use too much binder, otherwise the mortar consistency is too fluid and the fine grained clay accumulates on the mortar surface during application. 	<ul style="list-style-type: none"> - Dry cleaning of areas with soft brushes and air blower. • When producing the mortar: <ul style="list-style-type: none"> - Filler: Mix first one part of the sand with the clay. Then add the sand part by part, while always mixing thoroughly before adding the next portion of sand. - Mixture Binder/ Filler: Mix first one part of the filler with the binder, then add the filler part by part, while always mixing thoroughly before adding the next portion of filler. <p>Application of mortar with spatulas on surfaces pre-consolidated with conservation material 1a or 1b (see section 1).</p> <ul style="list-style-type: none"> - Before the rendering mortar is applied it should be assured that the plaster edges are stable enough, possible other necessary conservation treatment of the paint layer and plaster might have to be carried out first in fragile areas before the rendering is possible. - The mortar must be thoroughly applied onto the plaster edges and the gaps behind these without leaving airholes or cracks between masonry and plaster. - A good connection to the aligning brick sides and underlying void mortar should be guaranteed. - When used for mortar fillings: A good connection to the aligning and underlying original plaster should be guaranteed. - The mortar should be applied to the niveau/ surface level of the thin original white plaster layer to secure the fragile plaster edges too.

	Make sure to always cover the mortar material you do not use immediately- to prevent it from drying out.
<p>5b) Second step- consolidation of rendering mortar (only in outside-areas)</p> <ul style="list-style-type: none"> • 10% Ludox PX 30 → in demin. water (80%) with Ethanol (10%) 	<p>Application with syringes - after drying of rendering mortar.</p> <ul style="list-style-type: none"> - Application of whole bricks along the plaster edges, of bricks behind the plaster edges as far as reachable and of joint mortar - Make sure that the surface is evenly soaked with the consolidant. - Then leave to dry - Very clean working is necessary- the Ludox PX 30 cannot be removed after drying!
<p>5c) First step- Mortar fillings of lacunae and defects within thin white plaster layer on clay plaster (mortar applies to material 4a).</p> <ul style="list-style-type: none"> • Binder: 1 % Tylose 10.000 in demin. water Filler: Marble powder : Sand → 1 : 3 (volume parts) <p>Sand: Desert sand washed and dried Marble powder: 32 μm Mixture Binder/ Filler: 1 : 6 (volume parts)</p> <ul style="list-style-type: none"> • Or: Mixture Binder/ Filler: 1 : 5 (v. p.) → For outside areas, where mortar dries faster. <ul style="list-style-type: none"> - Do not use too much binder, otherwise the mortar consistency is too fluid and the fine-grained marble powder accumulates on the mortar surface during application. 	<ul style="list-style-type: none"> - Dry cleaning of areas with soft brushes and air blower. • When producing the mortar: <ul style="list-style-type: none"> - Filler: Mix first one part of the sand with the marble powder. Then add the sand part by part, while always mixing thoroughly before adding the next portion of sand. - Mixture Binder/ Filler: Mix first one part of the filler with the binder, then add the filler part by part, while always mixing thoroughly before adding the next portion of filler. <p>Application of mortar with spatulas on surfaces pre-consolidated with conservation material 1a or 1b (see section 1).</p> <ul style="list-style-type: none"> - Before the mortar is applied it should be assured that the plaster edges are stable enough, possible other necessary conservation treatment of the paint layer and plaster might have to be carried out first in fragile areas before the mortar application is possible. - The mortar must be carefully applied into the lacunae and defected areas without leaving airholes or cracks along the edges between filling and surrounding original plaster. - A good connection to the aligning and underlying original plaster should be guaranteed. - The mortar should be applied to the surface level of the thin original white plaster layer to secure the fragile plaster edges too. <p>Make sure to always cover the mortar material you do not use immediately- to prevent it from drying out.</p>
6. Injection grouts for lime and clay plaster consolidation	
Conservation recipe/ composition	Application/ procedure
6 a) Grout for the injection of voids between plaster and mud brick masonry- thin voids	<ul style="list-style-type: none"> - Dry cleaning of area with air blower <p>Application with syringes,</p>

<p>Binder: 1 % Tylose 10.000 in demin. water + Ludox PX 30 (pure) (Mixture: 1:1 in volume parts)</p> <p>Filler: Marble powder : micro glass bubbles → 1: 1 (in volume parts)</p> <p>Mixture Binder/ Filler: 1 : 2 (volume parts): 1 volume part: Binder 1 volume part: Marble powder, 1 volume part: Micro glass bubbles</p>	<p>First pre- consolidation and slight wetting with 1% Klucel E in Ethanol (89%) with demineralised water (10%) (see section 1).</p> <ul style="list-style-type: none"> - Leave to dry - Then injection of fine grout - Very clean working is necessary- the Ludox PX 30 cannot be removed after drying.
<p>6 b) Grout for the injection of thin detached areas between plaster and masonry</p> <p>Binder: 2 % Klucel G in Isopropanol¹² (88%) with demin. water (10%)</p> <p>Filler: Marble powder : micro glass bubbles → 1: 1 (measured in volume parts)</p> <p>Mixture binder/ filler: 1 : 1,5 (volume parts)</p>	<p>Application with syringes:</p> <ul style="list-style-type: none"> - First pre- consolidation slight wetting of the hollow areas between plaster and masonry with 1% Klucel E in Ethanol (89%) with demineralised water (10%) (see section 1). - Leave to dry - Then injection of fine grout <p>If the volume of the hollow areas is larger, the grout should be injected in 2 to several steps while leaving the previous injection to dry before injecting more material</p>
<p>6 c) Grout for the injection of thin scales within or between plaster layers and compact white wash scales</p> <p>Binder: 1 % Klucel G in Isopropanol (89 %) with demin. water(10 %)</p> <p>Filler: Marble powder + micro glass bubbles → 1 : 1 (measured in volume parts)</p> <p>Mixture Binder/ Filler: 1 : 1,5 (volume parts)</p>	<p>Application with syringes:</p> <ul style="list-style-type: none"> - First pre- consolidation and slight wetting of the hollow areas between plaster and masonry with 1% Klucel E in Ethanol (see section 1). - Leave to dry - Then injection of fine grout - If the volume of the hollow areas is larger, the grout should be injected in 2 to several steps while leaving the previous injection to dry before injecting more material to prevent shrinking cracks
<u>7. Structural consolidation of paint layer</u>	
Conservation recipe/ composition	Application/ procedure
<p>7 a) 1 % Klucel E → in Isopropanol (89 %) with demin. water (10%)</p>	<ul style="list-style-type: none"> - Dry cleaning of area with soft brushes and air blower <p>Application with syringes or for bigger areas by spraying with a vaporiser pump-spary bottle that produces a very fine mist. This method enables the application without touching the original surface.</p> <p>Where the paint layer is powdering the consolidant should only be sprayed on the surface- even fine brushes should not be used as the paint layer there is to fragile to prevent pigment reduction with the brush.</p>

¹² If isopropanol was not available ethanol was used as alcohol instead in this and other consolidation recipes.

	Very fine, soft brushes can be used for application in more stable areas; here a Japanese paper can be used as a protection layer between brush and wall painting surface.
7 b) 2 % Klucel E → in Isopropanol (88 %) with demin. water (10%)	If more consolidant is needed to reach the necessary consolidation this Klucel E percentage can be used for the paint layer conservation. The application applies to the description in 7a.
8. Grout for the injection of whitewash/ paint layer scales	
Conservation recipe/ composition	Application/ procedure
8 a) Fine injection grout with filler Binder: 2 % Klucel E → in Isopropanol (88 %) with demin. water (10%) Filler: Marble powder + micro glass bubbles → 1: 1 (measured in volume parts) Mixture Binder/ Filler: 1 : 1,5 (volume parts) + Brownish pigment 1 volume part: binder 1,5 volume part: filler	- Dry cleaning of area with soft brushes and air blower Application with syringes: - First pre- consolidation and slight wetting with 1% Klucel E in Isopropanol - Leave to dry - Add only very small amount of pigment to the injection grout to break the whiteness and match the colour of the plaster; suitable pigments for Tuna el Gebel i.e.: Brown ochre, terra di sienna, burnt umbra "cyprisch" - Then injection of the fine grout - Leave to dry
8 b) Viscous Klucel-Gel for the consolidation and reattachment of thin white wash and paint layer scales without filler • 1% Klucel M → in Isopropanol (89%) with demin. water (10%)	- Dry cleaning of area with soft brushes and air blower - Application with soft brushes behind the scales. - To reattach the scales to their plaster support, they can be gently pressed down with a soft brush or, in case of stronger scales with a little stamp made of Hostaphan-foil and cotton inside.
9. Japanese paper facings	
Conservation recipe/ composition	Application/ procedure
• 1,5% Klucel M → in Isopropanol (88,5 %) with demineralised water (10%)	Application on fragile paint layer and plaster sections to prevent further loss. - Dry cleaning of area with soft brushes and air blower. - The consolidant is applied on the backside of the cut out Japanese paper piece. - Then the paper can be applied on the fragile surface with a soft brush.



Fig. 6, 7: Graphic documentation before treatment in GB 26 (M9d/SE) assessing the asset and occurring damages. Dry cleaning of surfaces with soft brushes in GB13 (M5/SS).



Fig. 8: Conserving the tomb pillar of Hermokrates (GB 20); application of mortar renderings for the painted lime plaster after grouting cavities between plaster and mud brick.

Fig. 9: A structurally stabilised painted clay plaster fragment with painting on a thin lime plaster layer and white wash is protected further by renderings with conservation mortar along the edges.



Fig. 10: Pre-consolidation of fragile stucco and plaster edges and the underlying adobe masonry, on the outside wall of tomb house GB 26 (M9d/SE). Photographic documentation during treatment.



Fig. 11: Field school 2018- in the courtyard of the excavation house at Tuna el-Gebel. Collective preparation of conservation materials with the recipe handout (see tab. 1) before heading out to site again.



Fig. 12: Field school 2018- Application of plaster renderings with conservation mortar in GB10 (M3/SS). Thin green tubes have been included for later grout injections. Fig. 13: GB 24 (M09/SE), grouting of smaller hollow areas within painted plaster surfaces was done directly with syringes and cannulas.



Fig. 14, 15) Exemplary use of Japanese paper facings to protect endangered painting areas. The painted surface of the tomb pillar of Hermokrates (GB 20) was covered with a beeswax coating in a former undated treatment. In some areas painting flakes had rolled up with the high-tension coating. These could be held in place with the paper facings and further damage halted. -Until being carefully rolled down with a special heating iron tool by simultaneously melting and removing the coating material over Japanese paper.



Fig 16, 17) East wall in main room of tomb house GB33 (M20/SE), the fragile wall painting fragment was stabilised in several campaigns receiving emergency conservation treatment to prevent the collapse of the Horus figure. Condition with first emergency treatment in 2010. Fig. 17 showing the condition after the treatment in the field school 2015. This included temporary Japanese paper facings, structural conservation of the plasters and paint layer, grout injections of cavities or the stabilisation of plaster edges, cracks and lacunae with conservation mortar. Within the thin white lime plaster wash finer light yellowish-white conservation mortar was used.

4. [Conclusions](#)

The emergency conservation measures conducted during the field schools successfully achieved the most urgent stabilization of endangered plasters and wall paintings in selected tomb houses preserving the asset for the present time. However, the original materials remain fragile and could need further conservation exceeding emergency treatment. Deterioration causes will continue to impact the fragile ancient plasters and wall paintings due to their permanent exposure and easy accessibility. Continuous conservation efforts will be necessary for generations to come, because conservation of such a large cultural heritage site is a huge challenge. Alongside the implementation of practical conservation measures a continuous maintenance concept would be essential for the long-term preservation of the archaeological mud brick architecture and its painted plaster surfaces. With joint efforts it will be necessary to accomplish this task.

5. [Bibliography](#)

Feller and Wilt 1993

Robert L. Feller, Myron Wilt: Evaluation of Cellulose Ethers for Conservation, research in Conservation 3/1990, Getty Conservation Institute, second reprint 1993.

Horie 2010

Charles Velson Horie, Materials for Conservation, organic consolidants, adhesives and coatings, London 2010.

ICOMOS ed. 2004a

ICOMOS ed.: Charta von Venedig (1964), S. 37-39; in: Monuments and Sites 1. International Charters for Conservation and Restoration. Second Edition, München 2004.

ICOMOS ed. 2004b

ICOMOS ed.: Charta von Lausanne. Charta für den Schutz und die Pflege des archäologischen Erbes (1990), S. 83-90; in: Monuments and Sites 1. International Charters for Conservation and Restoration. Second Edition, München 2004.

Lembke – Prell 2015

Katja Lembke – Silvia Prell (eds.) 2015, Die Petosiris-Nekropole von Tuna el-Gebel Vol. 1, Tuna el-Gebel 6 (Vaterstetten 2015) 260–303.

Lembke et al. 2007

Katja Lembke, Jana Helmbold-Doyé, Christine Wilkening, Alexandra Druzynski von Boetticher, Claudia Schindler: Vorbericht über den Survey in der Petosiris-Nekropole von Hermupolis/Tuna el-Gebel (Mittelägypten) 2004-2006, S. 71-127; in: Archäologischer Anzeiger (2007/2), Berlin 2007.

Lindner – Quast 2007

Olaf Lindner, Astrit Quast: Arbeitsreport, konservatorische und restauratorische Maßnahmen an den antiken polychromen Wandfassungen, Nekropole Tuna el-Gebel (Mittelägypten), Oktober 2007, S. 1-5; unveröffentlichter Konservierungsbericht zur Grabungskampagne 2007.

Schindler 2007

Claudia Schindler: Restaurierung, S. 115-122; in: Lembke et al. (2007)

Simon et al. 2009

Stefan Simon, Marisa Pamplona, Sabine Schwerdtfeger, Regine- Ricarda Pausewein:
Untersuchungsbericht 47-58_052005, 12 Stückfragmente aus Tuna el-Gebel, S. 1-74;
unveröffentlichter Untersuchungsbericht, Rathgen Forschungslabor, Berlin 2009.

Schulz – Schulz 2010

Martina Schulz, Henrik Schulz: Analysenbericht [011209]; unveröffentlichter naturwissenschaftlicher
Untersuchungsbericht v.a. von Pigmentproben aus der Petosiris-Nekropole, Hildesheim 2009.

Stanley-Price 2004

Nicholas Stanley-Price (ed.), Conservation and management of archaeological sites, Volumes 6,
Numbers 3 & 4, London 2004.

Torracca 2009

Giorgio Torracca: Lectures on Materials Science for Architectural Conservation; Getty Conservation
Institute, Los Angeles 2004.

Winkels – Riedl 2015

Alexandra Winkels, Nicole Riedl, Entwicklung von Putz- und Maltechnik in der Petosiris-Nekropole
von Tuna el-Gebel. Erste Untersuchungsergebnisse zu Akkulturationsprozessen in der Region
Mittelägypten, in: K. Lembke – S. Prell (eds.), Die Petosiris-Nekropole von Tuna el-Gebel Vol. 1, Tuna
el-Gebel 6 (Vaterstetten 2015) 260–303.

Winkels 2010

Alexandra Winkels: Konservierungsbericht der Grabungskampagne 2009. Dokumentation der
durchgeführten Maßnahmen an Fundobjekten und der Konservierung der Grabstele des
Hermokrates, GB 20, S. 1-28 und Anhang, unveröffentlichter Konservierungsbericht, Freiburg 2010.