Painted Surfaces On Mud Plaster And Three-Dimensional Mud Elements: The Status Of Conservation Treatments And Recommendations For Continuing Research

Constance S. Silver

1. Introduction

The Greco-Roman sites of the Dakhleh Oasis, Egypt, contain outstanding architectural decoration executed in late antiquity. Classically inspired mural paintings, late Pharaonic religious murals, tomb paintings, lengthy inscriptions in literary Greek, and a modeled and decorated niche, have all been found and will continue to be uncovered as excavations go forward.

Remarkably, this complex and beautiful corpus of cultural material has humble origins: it is created mostly from mud plaster or modeled mud, although there is also some modeled gypsum plaster, and embellished with simple tempera paints. Thus, although diverse in appearance and function, these examples of architectural finishes and elements have two things in common, their overall technique of execution and the often idiosyncratic nature of their component materials and state of preservation. Unfortunately, these essential physical constituents always prove challenging for, and sometimes resistant to, conservation treatment.

The broad purpose of this paper[1] is to provide a status report on the conservation problems that have been encountered, and the treatments developed, in the course of several years of excavation, study and implementation at the site of Amheida. This paper will focus on:

(1) Overviews of the physical nature of the mural paintings and related cultural property found at Amheida and in other archaeological sites in the Dakhleh Oasis;

(2) Conservation problems encountered to date;

(3) Conservation treatments that have been developed;

(4) Conclusions about the current status of treatments.

2. Background

The type of mural painting encountered in the Dakhleh Oasis is found all over the world and in many periods and cultures. Structural supports may be natural rock caves, cut-stone masonry or mud-brick walls, but all are finished with mud plaster. A white or otherwise light-toned ground is applied to the mud plaster to create a suitable surface for painting. Typical constituents of the ground are clays, calcium carbonate and calcium sulfate.

Almost always, the paint is made from a water-soluble tempera medium such as a vegetal gum or animal protein. Usually the pigments are naturally occurring materials, although synthetic pigments also have been used, for example, on the Buddhist murals and sculpture of Central Asia. Indeed, murals and sculpture from Buddhist caves in Central Asia provide a good example of this recurring shared technique of execution (Plate 1). Evident in the photograph are the modeled mud surface and mud plaster. A white ground has been applied, followed by characteristically soft almost pastel-like and matte-textured tempera paints.

This technique of execution results in a subtle and matte appearance of the painted surface, but it also creates a work that is inherently fragile, friable, water-sensitive, very soft and with poor tensile strength. However, the most challenging problem is the extreme sensitivity of these materials to conservation treatment; that is, the ease with which their appearance can be irreversibly altered by use of traditional and synthetic conservation materials. The very low ratio of binder to pigments, the fragility of the binders and the weak refractive index of the white ground and paints bear most of the responsibility for this poor resistance to alteration during treatment.

As a result, consolidants or fixatives, especially synthetic resins, almost always alter the refractive index and provoke unacceptable changes in optical qualities. Specifically, the colors appear to darken and become

[1] This paper focuses on specific technical issues of conservation treatment. Other issues of conservation and preservation encountered in the House of Serenos are discussed in Silver 2008.

muddy, especially the light and white tones. This is an optical effect caused by the darkened brown tone of the mud plaster showing through the altered white ground, medium and pigments. Further, the painted surface almost always changes from the original soft-toned and matte appearance to a hard, dense and glossy texture. These changes are practically irreversible and effectively ruin the mural painting or painted object.

This conservation problem is by no means unique to tempera painting on mud-based surfaces. Similar decorative techniques, such as pastel, tempera paints, watercolor, gouache, and *fresco-secco* to varying degrees may also suffer irreversible changes in appearance as a result of ill-advised consolidation. Indeed, this conservation problem is so pervasive and challenging that it has been the subject of a major technical study in 1993 that focused on ethnographic objects decorated with tempera paints.[2] The many problems and concerns identified in the 1993 study are magnified when exacerbated by friable mud supports, weak mud plaster and the on-site work venue in the hot sun and dust storms.

3. Conservation Treatments for the Mural Paintings of Amheida

During the period since 2003, mural paintings from three sites in the Dahkleh Oasis—Kellis, a necropolis of Mut, and Amheida—have been treated. (Work on the Kellis paintings began earlier than at the other two sites.) Briefly summarized, for pieces and fragments of murals from the Temple of Tutu, Kellis, treatment has entailed the detachment of the murals from the mud-brick and mud plaster substrates. A conventional treatment is used: application of supportive facings of tissue paper, adhered with Acryloid resin dissolved in a solvent such as acetone. While the surface of the mural is supported with the facing, the mud brick and mud plaster can be removed mechanically from the back. Resin-based consolidants, as dispersions or emulsions, are used to strengthen the mud plaster and ground. The facing eventually is removed with solvents.

Egyptian conservators have carried out extensive and ambitious conservation work on the mural paintings and structures of the necropolis of Mut. They have employed a similar approach: resin-based facings support the painted surface of the mural during detachment and remounting.

Apparently, no serious changes in appearance resulted from use of these resin-based adhesives, fixatives and consolidants. This is an unusual and welcomed outcome because tempera murals on mud plaster at other sites around the world, such as Teleilat Ghassul (Jordan), Mesa Verde National Park (Colorado), Acoma Pueblo (New Mexico), and Çatal Hüyük (Turkey) were subject to permanent darkening and other changes in appearance when treated with resin-based materials.

A mural painting on mud brick and mud mortar from the Chalcolithic site of Teleilat Ghassul provides the cautionary tale. It was treated in Jordan in 1979.[3] It is an excellent model for many of the conservation problems encountered at Amheida, including the risks associated with the use of resins. During the course of conservation treatment, it was ascertained that the friable tempera paint would require an application of a light fixative. A diffuse spray of Acryloid B72, about 3 percent, was effective as long as it did not saturate the surface. However, a small area of saturation did occur. The visual alteration of an important detail, a bracelet on the hand of a deity, was so altered that it virtually disappeared. A great deal of inventive remedial conservation work was required to extract and dilute the resin from this area so the detail could be retrieved.

The outstanding classical mural paintings of the reception hall of the House of Serenos (Area 2.1, B1), Amheida, proved to be the rule rather than the exception: not only have they been in poor condition (the combined result of damp, insects, and unauthorized visitors), they have been very difficult to treat (Plates 2 and 3). The technique of execution explains the murals paintings' poor response to most treatments. First, the white surface preparation applied to the mud plaster is remarkably thin and has a very low refractive index. Second, all the pigments, but especially the whites, proved to have a very low refractive index. Third, the murals are very thinly painted. Fourth, the ratio of binder to pigment is quite low. Thus, any infusion with a resin-based consolidant caused darkening. By contrast, the murals from Kellis and the necropolis of Mut are executed on much thicker white grounds. It is also very likely that different, more resistant, whites were used for the mural paintings' grounds but this remains a hypothesis for the present.

Conservation treatment in the House of Serenos was guided philosophically and procedurally by one of the foundations of conservation, minimum intervention. The objective of the conservation treatment is to

[2] Hanson, Walston, and Bishop 1993. An excellent condensation of key information in this 600-page book is available on-line through the *WAAC Newsletter* 18, Number 2, May 1996.

[3] Schwartzbaum, Silver, and Wheatley 1979.

leave the cultural property as little changed as possible.[4] In the House of Serenos, four distinct conservation problems became evident:

1. *In situ* Conservation of Mural Paintings. The reception hall and other rooms and spaces retain outstanding mural paintings on the walls, sometimes to a height of almost 3 meters. The goals of the conservation treatment were to stabilize the mural paintings so they could be safely excavated, cleaned, documented, and then protectively backfilled.

A variety of conservation materials were tested on fragments of mural paintings. These materials ran the gamut from synthetic acrylic resins to Ethulose and naturally occurring sturgeon glue.[5]

Eventually, Acryloid B67, highly diluted to 3 percent in acetone, was selected. A very light sprayed application was applied to the cleaned surface in order to fix the friable paint. Perfume bottles acquired locally provided the best spray—very fine and with little force. The fixative was never allowed to infuse the painted surface, but rather to settle in a somewhat discontinuous film on the surface. Plate 4 shows just how dark the mural will become if saturated: compare the saturated figure on the right to the unsaturated figure on the left.

In the reception hall of the House of Serenos, localized areas of unstable mud plaster were treated by application of Lascaux Hydrosealer 750® diluted to 50 percent in water. This (butyl methacrylate) dispersion is characterized by the very fine size of its solids, low viscosity and ease of dilution in water. Using eye droppers, it was applied locally between the mud brick and mud plaster, into cracks, borders and holes that had been lightly pre-wetted with water. Many sections of mud plaster were so unstable they had to be reinforced with a mud putty amended with Lascaux Hydrosealer 750® applied around the edges to act as a support.

It can be confirmed that this on-site conservation treatment, characterized by minimum intervention, worked well because the murals of the reception hall were backfilled and subsequently re-excavated. Thus, it has been possible to assess condition two years after treatment and backfilling.[6] The mural paintings were stable. However, one problem was observed: the backfill material should not be sieved because it concentrates the fine dirt-like silts, which soil the mural paintings.

It is important to protect the murals during excavation, to avoid rapid and excessive drying from the heat of the sun and the strong winds that occur at the site and can abrade the mural's surfaces because of the heavy dust and sand they carry. Many archaeological sites utilize temporary shelters over areas of sites that are being excavated, especially if those areas preserve important and easily damaged cultural material like mural paintings.

At Amheida, construction of temporary shelters has been problematic, due to three problems. The first problem is the extremely strong wind that can arise very suddenly. In order to avoid a potential safety hazard, any shelter at Amheida would require engineering sufficient to resist collapse from extreme wind loads. Second, a shelter could protect against sun, but it would not necessarily protect against abrasion from wind-borne particulates. Third, Amheida is a very large and easily accessible site that cannot be uniformly patrolled at night. A costly shelter could present temptation for theft, and it can be assumed that damage to the site would occur in the process.

To address these concerns, a simple and inexpensive system was developed for protection of the mural paintings during excavation. White sun-reflecting fabric was stapled to a long and robust piece of wood at the top, and to a smaller piece on the bottom. These simple materials create an extendable shade that can easily be moved around as excavation progresses. The shade was secured to the top of a wall with mud bricks. Flaps were cut to minimize the force of the wind on the fabric. Like a window shade, the fabric can be pulled down over the wall to protect the mural during excavation and at night, or sections during treatment. This unobtrusive, "low-tech" and inexpensive construction has not provoked any attempts at theft.

2. Detachment of Mural Paintings from Masonry Blocks. A difficult conservation problem entails the detachment and remounting of pieces of murals, especially those on large, very heavy and unstable blocks of

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[4] See Silver 1993. The concept and practice of minimum intervention as applied to several types of tempera mural paintings is explored in this paper.

[5] Ethulose is ethyl hydroxyethyl cellulose. This class of fixatives, cellulose ethers, have been useful for reinforcing many fragile materials which are susceptible to changes in appearance and staining. However, the long-term stability of some has been questioned. See Feller and Wilt 1990.

[6] See Silver, Snodgrass, and Wolbers 1993. Plaster on masonry was conserved at Aztec Ruins National Monument. The first scientific backfill system for a mural painting on a mud rendering was developed and implemented. In 2005, the backfill was partially removed to determine the condition of the mural painting and of the backfill system itself. Both were found to be in excellent condition.

masonry. As always, the great challenge was to find and successfully employ materials that will not change the original optical qualities of the mud plaster, white ground and paints, while also increasing much needed strength in the mud brick and mud plaster.

About fifty-five painted masonry blocks were removed from the reception hall, the result of collapse of walls and the dome following abandonment in antiquity. Some blocks were small, no more than 10 x 12 x 7cm. Others were quite large, measuring 1.3 x 1 x 0.20 m, and extremely heavy.

The immediate treatment objective was to strengthen and then remove the mural paintings from their blocks, preserving the painting on a section of consolidated plaster and mud brick. This treatment is the first step preparatory to remounting a section of mural painting on a permanent support.

Two materials transported from the United States made this treatment possible. The first, cyclododecane (1-ethoxyethoxy - C16H32 02), has revolutionized all fields of conservation treatments.[7] This wax-like material was used as the adhesive for supportive facings applied to the murals. However, its remarkable properties allow it to evaporate away over time. Thus, it leaves no residue that can cause the darkening or other permanent alteration of the original appearance of the painting.

The consolidant was *Conservare OH*®, which is popularly referred to as an "ethyl silicate" consolidant. Briefly and simply described, this type of consolidant infuses silica into the fabric of the mud brick, mud plaster and paint. Silica is naturally present in the mud brick and mud plaster. The consolidant strengthens by creating a silica lattice-work from grain to grain and particle to particle. In a broad sense, the mud brick and mud plaster are transformed into a low-grade synthetic sandstone. Changes in optical properties rarely occur. Any changes that do occur almost always are minor.

Again, the Teleilat Ghassul project, undertaken in Jordan in 1979, provided an excellent model for the conservation work carried out on mural paintings on collapsed mud-brick blocks from the House of Serenos. The painted surfaces were lightly fixed and then supported and protected with facings. The thickness of the mud-brick blocks was reduced. A plaster receptable was made for each block. The blocks were then consolidated by allowing the consolidant to rise in the mud brick and plaster through capillarity.

Wacker OH®, imported from Germany, was the consolidant. It is an "ethyl silicate" consolidant. The results were excellent: the mud brick and mud plaster were safely consolidated and the painted surfaces retained their original appearance. Over the last 30 years, the Teleilat Ghassul mural has remained in perfect and stable condition in the National Museum in Amman.

For the blocks of murals retrieved from the House of Serenos, a very similar treatment was implemented. The blocks were protectively faced with cyclododecane and synthetic crepaline. Using standard drills with masonry bits, a row of vertical holes was drilled through the block, about 8 cm below the painted surface. Various types of hand saws were then used to cut between the drill holes. As the sawing progressed, a metal plate was inserted into the saw cut, until the reduced section of the block sat on the metal palette.

The selected consolidant was *Conservare OH100*®, supplied by the American company, ProSoCo. Although the exact formula and provenance of its components are proprietary, it does contain ethyl alcohol and ethyl silicate. It is believed to be very similar to the *Wacker OH*®. A rim was built up in silicon on the metal plate, around the perimeter of the block, to create a receptacle. The consolidant was slowly poured into this improvised *de facto* vessel and allowed to diffuse into the reduced width of the mud brick and plaster through capillary rise.

The consolidation occurred quickly and was successful. Friable mud brick and mud plaster were greatly strengthened; indeed, the white ground and painted surface also were strengthened. Virtually no change in optical qualities resulted. However, it did take several months for all the solvent to evaporate out of the dense mud brick (Plate 5).

The negative side effect was some cracking of the largest blocks, primarily at the perimeters and into the painted surfaces. Cracking of both stone and mud brick after consolidation with an ethyl silicate consolidant has been reported by several researchers, but the precise reason for this problem is not clear.[8] The most likely explanation is the presence of the clay fraction in any given material, be it mud brick or stone. Indeed, researchers have dubbed this "the clay problem." Many clays can be highly reactive, swelling and shrinking in response to contact with various types of liquids.

Hence, a likely explanation is that a specifically reactive clay is a natural inclusion in the mud brick, mud plaster and perhaps even the white ground used to create the mural paintings in the House of Serenos. The

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8 Wheeler 2005, 43–45.

clay probably swells during consolidation, which causes cracking by provoking dimensional changes in the mud brick and mud plaster.

The explanation of clay as the vector that provokes cracking seems supported by similar conservation case histories. At the highly important Neolithic site of Çatal Hüyük, Turkey, cracking of mural paintings during and after consolidation with *Wacker OH*® was so severe that it could not be used. On the other hand, consolidation of very fragile prehistoric murals on mud plaster at Aztec Ruins National Monument, New Mexico, in 2009 using *Conservare OH100*® was remarkably successful: the plaster was consolidated along discrete areas of fragile borders, resulting in excellent localized strengthening with no changes whatsoever in appearance or cracking (Plate 6). The mural painting from Teleilat Ghassul suffered no cracking or spalling of the surface during or after consolidation with *Wacker OH*® and has remained in excellent condition for 30 years.

The larger blocks from the reception hall in Amheida B1 were more prone to cracking. The smaller ones remained stable. The occurrence of the side effect of cracking thus seems clearly linked to the different constituents and properties of each type of mud brick and mud plaster, as well as the relative concentration of the reactive agent in each mix and application of mud. As all mud plasters contain a clay fraction, it seems increasingly likely that some types of clays will be reactive when they come into contact with an ethyl silicate consolidant. Conversely, other types of clays will be non-reactive, resulting in dimensional stability during and after consolidation.

The cracks that occurred in the large blocks and their painted surfaces are very fine. Eventually, they can be repaired using original materials derived from expendable plaster found at the site. Clearly it is hoped that this problem may be mitigated by refinement of the consolidation process following further research. However, there is a also a strong possibility that some, but not all, mud brick and mud plaster in the Dakhleh Oasis always will suffer some cracking during consolidation.

The current widths of the larger blocks will need to be reduced further prior to remounting. Reduction in the width of the blocks can be achieved by reapplication of cyclododecane facings followed by mechanical reduction of the mud brick to a uniform desired width. There are many precedents for materials and systems used for remounting detached murals, derived from decades of conservation work on true frescoes in Italy and other countries.

3. Fragments of Mural Paintings. Hundreds of small but beautiful fragments of mural paintings were retrieved from the reception hall of the House of Serenos (Plate 7). Several fragments eventually were realigned into their original configurations to reconstitute small but important scenes.

The fragments present their own unique set of problems. First, the fragments are very friable and brittle; they will require consolidation. Tests carried out thus far indicate that consolidation with resin-based materials will not provide an acceptable result because of darkening of the component materials and poor absorption of the consolidant. It seems likely, therefore, that an ethyl silicate consolidant will be required.

Perhaps the most challenging problem is the almost total inconsistency of thickness from fragment to fragment. Some fragments are relatively thick because they remain attached to mud plaster and some mud-brick. Other fragments remain attached only to very uneven strata of mud plaster, while other fragments are very thin because they are composed only of the white ground and painted surface.

Following consolidation, a uniformly consistent thickness, must be created on the back of each fragment that is slated for remounting and reconstitution within a scene composed of related fragments. Hence, the backs of some fragments will need to be reduced, while others will need to be built up. The fragments must be further reinforced and stabilized on the reverse with, for example, a very fine synthetic crepaline fabric applied with a reversible adhesive.

Fragments can then be mounted on reversible museum mounting board with a reversible adhesive. Museum mounting board is readily available and inexpensive. It provides an additional benefit: the board can be easily trimmed around the edges of the mounted fragment to create individual pieces. Like the pieces of a jigsaw puzzle, fragmented but contiguous pieces of a scene can be joined together. Additional mural fragments can be added to a scene if and as they are discovered and identified.

4. Other Conservation Problems

Treatments need to be developed for two other conservation problems, detachment of a large mural from a wall and the stabilization of three-dimensional painted objects modeled from mud.

The detachment of a large mural from a wall and its conservation treatment and remounting to museum standards is a challenge on all accounts. Many concerns, both philosophical and practical, militate against the detachment and relocation of murals and other architectural elements from their original locations in or on a building. However, an emergency may require removal of a mural painting or other architectural

element from the site.[9] Or, there may be the rare occasions when it is desirable to relocate a uniquely outstanding mural or architectural element to the museum. The extraordinary Greek inscription found in the "classroom" of the House of Serenos raises this spectre (Plate 8). Thus, it is prudent to begin to think about how this challenge can be successfully met should the situation arise.[10]

The mural paintings found thus far at Amheida have been quite delicate in construction, generally characterized by rather thin application of mud plaster to the mud brick walls. The mud plaster tends to be weakly bonded to the wall. Consequently, a system used for detachment must not provoke collapse by over-weighting the plaster with heavy facings. Clearly, extensive testing on an unimportant and expendable area of white plaster will be needed to develop any detachment system, but a multi-phased treatment will be required. The following treatment outline describes a possible approach to treatment:

1. Document the mural.
2. Make a tracing of the entire mural.
3. Examine the mural and determine how it will be sectioned for detachment.
4. Mark the detachment sections on the tracing and other documentation. Number each section for identification.
5. Make a second tracing and cut out each detachment section with its number. These pieces will be used to identify each section during the course of the treatment, as may be required.
6. Construct a chambered support in front of the mural. The chambers will correspond to the sections to be detached.
7. Fill the chambers with sand to ensure that the mural, in its entirety, remains supported at all times.
8. Remove the first chamber and its sand, exposing the first section selected for detachment.
9. Secure the mural section with strips of gauze bolted into the wall and then adhered with cylcododecane.
10. Apply a gauze and cyclododecane facing to the entire section after it has been secured in step
11. Detach the section and take it to the on-site conservation facility, with its traced section adjacent for identification.
12. Remove the mud brick/mud plaster from the reverse of the section to a desired thickness.
13. Consolidate with an ethyl silicate consolidant.
14. Proceed to the next section of the mural painting.
15. Repeat the process until the mural painting has been detached.

Three-dimensional painted objects made from mud present a different set of problems. The decorated niche from the reception hall of the House of Serenos is an example of this category of cultural property. There are other outstanding examples of three-dimensional cultural property, modeled in mud and painted, found in other areas of the world. The exquisite and often enormous statues of the Buddha found in the caves the Silk Road are one example. However, there appear to be no immediate precedents for the conservation problems presented by the friable and fractured family shrine from the House of Serenos.

Clearly, development of a treatment for the family shrine will require considerable research and pilot conservation treatments on similar expendable materials, such a block of collapsed mud-brick masonry. The following very general conservation program can be anticipated. The shrine will require careful documentation, including development of a system that will ensure that chunks and pieces can be identified and replaced in their original position. The loose paint must be cleaned and secured. Next, the object first must be totally supported in a three-dimensional lattice made from facings and struts adhered with cyclododecane. Further reinforcement with, for example, fiberglass fabric and epoxy may also be needed to support the shrine during consolidation.

Because of the size and density of the modeled mud, consolidation will probably need to be effected by capillary rise from the base and by injection or infusion by a drip method into the mud substrate, from above. The entire piece may also need to be further supported internally with "pins". Broken pieces may need to be "pinned" in place as well as adhered with an adhesive. It is also possible that an external armature will be required to support the object after treatment.

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[9] In 2003, a Twenty-Fifth Dynasty wall painting on mud plaster, measuring 1.98m high and 2.72m wide, was removed from the Taharqo temple, Qasr Ibrim to save it from destruction by moisture. Consolidation from the back was undertaken with polyvinylbutyral B30H in acetone and alcohol. Developed in the British Museum over the last 25 years, the mounting system was made from carbon-fibre and foaming epoxy resin. A similar system was used in 1979 to remount the Çatal Hüyük mural in Jordan. See Singleton and Miller 2007.

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5. Conclusions

After several years of work, it can be concluded that the mural paintings, architectural finishes, and painted elements – all composed from mud and tempera paint – have presented many unexpected and unresolved conservation problems for conservators in the Dahkleh Oasis. A program of continuing research will be required to develop a full range of treatments. However, it is the strongly held position of this paper that solutions do exist and can be successfully applied to the conservation problems that have been described.

Based on the hard realities of demands made on conservators on-site during the excavation season, comprehensive conservation research cannot take place simultaneously with field work. Therefore, a dedicated program of conservation research independent of the excavation season will be needed. The extraordinary archaeological sites, range of conservation problems, strong collaboration from Egyptian colleagues, and excellent field facilities, can make the Dahkleh Oasis an international study center for the conservation of cultural property created from painted mud.

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President, Preservar, Inc.
15 Forest Street
Brattleboro, VT 05301
c.s.silver@att.net

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