Conservation Project TT 110 (Tomb of Djehuty)

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INTRODUCTION

In October of 2012, conservation work began on Theban Tomb 110 (TT110) associated with the ARCE Conservation Field School. Each season entails a 9 month intense conservation training program focusing on documentation and conservation applications. All of the trainees are conservation employees of the Ministry of Antiquities. The conservation program is directed by Khadija Adam, the ARCE Luxor Conservation Manager. Included with the documentation focus, the advanced program also includes technical investigation, stabilization and cleaning of the walls, and the reinforcement of the ceiling and existing pillars. ARCE Luxor trained 33 Ministry of Antiquity conservators within 3 seasons of work (27 months). Upon completion, flooring, handrail and solar powered lighting was installed for the opening to visitors.

DESCRIPTION OF THE TOMB

The Tomb owner of TT110, located in Sheik Abdel Qurna, was a nobleman by the name of Djehuty. He was the Royal Butler for Queen HATSHEPSUT who ruled from 1507 BCE to 1458 BCE. He was apparently successful in his work as he continued and was promoted sometime under THUTMOSIS III (ruled 1479 BCE to 1425 BCE) to a Royal Herald. The tomb is important from many reasons but one of the highlights is that both pharaohs are depicted in the tomb.

Tomb 110 is situated in the upper part of the gully which runs down from the height of Sheik Abdel Qurna in the Khoka area.

The tomb is T-Shaped, typical of the 18th Dynasty. The forecourt and the original access to the tomb, was completely buried under local housing structures for a long period of time. ARCE completed the clearance of the forecourt in 2015. The Transverse Hall contains two stelae, one located in the north wall and one located in the south wall. Inscribed on the stelae are the cartouches of Hatshepsut and

Figure 1 – The area before the clearance of TT 110 forecourt

Tuthmose III. The East and West walls are decorated with various scenes of the tomb owner including a false door in The South section of the West wall. The Corridor still contains original decoration on the north and south walls although they are badly damaged. The Pillared Hall is supported by two rock-cut pillars, and was full of debris when ARCE started work in the tomb.

Theban Tomb 110 was carved into an area of the limestone bedrock of Qurna that is very friable and of poor quality including many fault lines. Cracks and veins of chalk and calcite are also present.

It was necessary to identify the properties of the rock due to added fastening required to stabilize loose and potentially unsafe sections of the ceiling. The properties also provided a clue in the phasing of the damage that befell the original finished areas of the tomb.

Figure 2 - Plan view showing the relationship between TT 42, TT 110 and a tomb with an unknown owner

The tomb was heavily damaged by smoke and intense heat that caused the wall paint to oxidize. Through time, the structure of the tomb became unstable possibly by accumulation of debris and structures above the tomb. Many pieces from the ceiling and the wall paintings began to flake off. In addition, there are fault lines surrounding the tomb walls from inside. The oldest written record of the fault lines are attested from Theodore M. Davis notes in 1927. The notations clearly describe the damage of two cartouches of Hatshepsut located at the West wall, North section in the Transverse hall.

Figure 3 - Fault lines running through the cartouches of Hatshepsut showing the shifting of the wall sections.

Figure 4 - Scaling and detachment especially from the parts nearest to the ceiling.

Figure 5 - Transverse Hall, East wall, South section detail showing cracks, islands and areas of missing paint exposing the underlying plaster.

In addition to the structural issues, the heat and smoke damage to the pigments on the walls in the Transverse Hall and the Corridor, changed the physical and chemical characteristics of the paint components, making it difficult to identify the original color. The dark soot also covered much of the scenes and inscriptions. Some very small sections of original intact pigments survived due to fault line coverage utilizing mud plaster. The mud plaster patching was placed in the tomb before 1927.

Figure 6 - Color photo of the Transverse Hall East wall with the original entrance blocked. Note the blackened and damaged surface.

TREATMENT METHODOLOGY

The initial phase started with investigations of the materials, study and documentation of the characteristics of the decay phases, rehabilitation and recording system of all treatment processes, and maintenance applied to the exterior façade and entrance jambs (after archaeological clearance of the forecourt). All of the activities included a focus on the trainee’s progress and conservation skills through the program including teamwork with the ongoing archaeology project in the Forecourt, Pillared Hall, Shaft and burial chambers clearance.

The recording of temperature and humidity rates inside the tomb started sufficiently in advance before the conservation work began and continued throughout the conservation period until project completion. Coupled with the geological study, all of the data pointed to a state of relative stability between the temperatures 27 C$^{\circ}$ - 30 C$^{\circ}$ with a humidity range between 20 % - 35 % with little, non-significant change between night and day rates. Change was noted during the conservation process with approximately 7 conservation trainees inside (right side of the chart above).

Figure 7 (L) – Tracing generated from a photographic plate & Figure 8 (R) – Symbols used on the tracings to show the conditions of the section.

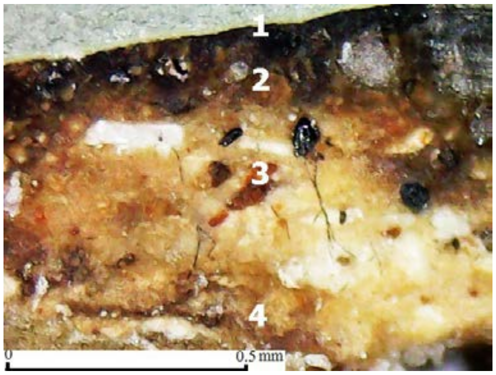
The ARCE Luxor documentation method is a sustainable technique that can be generated with or without a computer. The walls are photographed and divided into plates with its own unique identification. The plates are traced and used to record and map the existing condition of the section and the various layers within. Symbols, rather than color, are used in conjunction with the glossary for each layer including a report documenting the planned, and ultimately performed, conservation application. All documents are stored in the ARCE Luxor data management system.

This method allows the recording of all the existing condition phases and the conservation processes used for all areas of the wall with a very simple and clear system without utilization of a computer which is not always available to many conservators within the ministry. However, ARCE Luxor is planning on following the current documentation process with training in methods using computer applications.

The conservation project followed many nondestructive analysis methods. The techniques included high magnified digital photography, optical microscopy in P.P.L. R.P.P.L.C.N light, Scanning Electron Microscope (SEM), Energy Dispersive X-ray (EDX), Reflected Fourier Transform Spectroscopy, and X-ray Diffraction Analysis. All areas were investigated inside the tomb including the walls where techniques and materials associated with the plaster examining original corrections, plaster for preparatory and pictorial layers, plaster with pigments and the color degree intervention and mud plaster. Also we compared areas of layers and pigments that have been exposed to cases of high damage to areas that still retain much of the original condition

The FTIR investigation recorded the variations in the wavelengths and reflectance according to the materials encountered. The investigation proves the existence of Arab Gum found grouped absorbed at wavenumber 1655.1541^{cm-1}.

Pigment samples of area (1), (original condition situations) shows that its main component is that of a gypsum ($CaSO_4.2H_2O$) / anhydrite ($CaSO_4$) mixture used as the main binding and plastering material covering the walls. Limestone powder (Calcite, $CaCO_3$ / Dolomite, $MgCO_3$) was added to the plaster mixture as filling and hardening material. Red pigment on sample (1), is composed of a high percentage of red ochre (Hematite Clay Fe_2O_3). Arsenic has been found in this sample which may indicate the addition of Realgar (α-As_4S_4), as an arsenic sulfide mineral, with its orange-red color. The yellow color is composed of a high percentage of yellow ochre (Limonite Clay FeO (OH) NH_2O). The sample was originally contaminated with titanium oxide that gave the color an optical opacity. White pinkish color of sample (3), shows the existence of gypsum/limestone mixture in the base. Barium was also recognized in the EDX, mainly in the form of barium sulfate which is mainly a transparent mineral called Barite ($BaSO_4$), and is used as a filler or to modify consistency of the pigment. All samples showed sodium chlorides as Halite mineral, mostly formed because of ground water migration.
The Pigment samples of area (2), high damage situations) showed that its mainly composed of reddish black pigment possibly caused by copper (I) oxide or cuprous oxide Cu_2O called Cuprite mineral with its shining metallic brownish-red. Multiple weathering conditions may transfer this Cuprite into Tenorite (CuO) which is recognized by its black metallic color. Blackened pigment (dark patina) shows a very low content of coloring oxides. Carbon is the only possible reason behind this black pigment in either forms, mineralogical or organic. Iron ochre may cause a brownish-red pigment in the form of Hematite (Fe_2O_3), however with certain weathering conditions, it may transform into Geothite (FeO(OH)) which could change the brown to a black color. Earth green pigment is typically caused by Malachite ($Cu_2CO_3(OH)_2$). When Malachite is weathered it transforms to a brown to black color (Tenorite, CuO). Strontium Aluminate ($SrAl_2O_4$) is used also in this pigment to give an illumination luster to the color. Gypsum ($CaSO_4.2H_2O$) / anhydrite ($CaSO_4$) mixture is the main binding and plastering material covering walls. Limestone powder (Calcite, $CaCO_3$ / Dolomite, $MgCO_3$) is added to plaster mixture as filling and hardening material. All samples showed sodium chlorides as Halite mineral, mostly formed because of ground water migration.



Layer 1	Fine dark color 75 µm
Layer 2	Thin layer from Hematite 85 µm
Layer 3	Gypsum and limestone fragments 400 µm
Layer 4	Sand + Gypsum

Figure 9 - Cross section from Transverse Hall, East Wall, South section showing the layer sequences

The third area, located at the Pillared Hall, focused on a section of mud sheet plaster. EDX revealed a low percentage of aluminum and silica compared to the usual contents of clay minerals. We cannot assume that this mud sheet is composed of clays. The tests also show a strong composition of calcium, possibly in the form of calcium carbonate and calcium sulfate. X-ray diffraction of powder sample (1 and 2) shows the calcite crystals as an indication of a large percentage of limestone, while X-ray diffraction of powder sample (3 and 4) shows calcite ($CaCO_3$) crystals as well as anhydrite ($CaSO_4$). All samples contained sodium chlorides as Halite mineral, probably formed because of ground water migration.

The clearance of the original entrance activities started with removing the debris at a depth 4m to 4.5m with coordination and cooperation between the archeologists and conservators, both lending professional specialization.

Figure 10 (L) - The debris before removal above the main entrance and Figure 11 (R) - The debris removal in progress exposing the original entrance

After the clearance of the original entrance was complete, it was very clear that the tomb's facade had been cut into the bedrock and that the façade had suffered greatly from decay. This decay took the form of missing portions of the facade, cracks, and flaking.

Before and during ARCE's work, it was evident that the bedrock into which the tomb was cut suffered from many forms of decay, including decomposition of the rock and in some areas the rock suffered from powdering. The slope of the terrain above the tomb resulted in continuous granules of loose rock regularly falling down into the forecourt.

Both the decay and terrain factors resulted in sequential amounts of dust deposited on the forecourt's floor. To combat the ongoing cycle of decay, the next conservation phase addressed the bedrock mountain itself. This phase sought to shore up the sloping terrain by placing a few rows of mud brick and installing a plastic mesh on the slope to hold portions of the surface debris in place. The mesh was then covered by natural materials similar to the surrounding panorama to stabilize the area and also make it ascetically compatible.

The restoration work also dealt with the façade's cracks and areas of flaking stone. In preparation for this work, all dust in the cracks via air pumps was removed. Larger cracks were grouted with re-adhesive materials.

The goal of the masonry work and consolidation was to strengthen the lintel and shore up missing portions of the façade. This was done with the participation of a specialist in stone cutting and fitting; Master Mason, Frank Helmholz who works the season with Chicago House. With his assistance, missing portions of the façade were restored with the same kind of stone found in the area.

Figure 12 (L) – Showing the restored missing portion of the façade and Figure 13 (R) – Showing a cross section drawing of the restoration.

After clearing the original entrance to the tomb, the forecourt clearance continued and a section of the original enclosure wall was discovered. The conservation team utilized original stone from the clearance debris to stabilize the wall. Mixing materials with the original after we investigate the original components is a restoration process known as 'Anastylosis'.

Figure 14 - The discovery of a partial enclosure wall after the removal of the debris

Also included in the enclosure wall discovery were original remains of a plaster top cover. The plaster was protected and then covered with new plaster, utilizing the same ingredients as the original. This was done to show how the original looked like and also to protect the underlying remnants.

The removal of the debris at the original entrance not only exposed the façade of the tomb but it also exposed the jambs at the entrance. The jambs were not affected by the soot that was so prevalent in the tomb. Although damaged, the jamb scenes, in the original colored splendor, depict the tomb owner Djehuty making offerings. The conservation team stabilized both jambs and placed a clear protective barrier at the entrance.

Inside the tomb, restoration work began. Two plaster conditions were noted. On the lower levels, the plaster was very thick and soft, containing rough granules that formed part of the ancient artists' treatment to cover the bedrock's natural deformities. The plaster at the higher levels was thin and very dry, with many missing pieces and many detachments. It was necessary to consolidate the areas using Japanese paper strips and a light resin applied with feather brushes.

In the cleaning process, all surface dust, deposits and the dust base between plaster layers that had detachments were cleared. Also, the dust base between the portions of flaking layers and plaster layers were cleared to facilitate re-adhesion during the treatment phase by injection and protection of the edges with plaster.

P.L.M was used to treat the detachments coupled with binders and grouting mortar especially on the Transverse Hall's West wall. Some of the damage can be attributed to the load directly above the tomb.

As a result of the dryness, some areas of the paint layer experienced flaking. The areas appeared as 'island-shaped' and through decay, began to flake and separate from the plaster layers. Consolidation materials with a suitable viscosity were used to obtain good penetration without any side effects from film or reflections.

Figure 15 – Re-attaching flaking areas.

Figure 16 - Application of the grouting injection process in the filling of cracks and micro-cracks in the Transverse Hall.

Any masonry activity inside the tomb was used only in areas where structural necessity proved critical, such as lintels. The masonry was performed by the conservation team and used stones equal in quality to the original as determined from the previous geological investigations.

Many vertical and horizontal thin cracks were present. Some of the cracks created a network that affected the pictorial layer. This was especially prevalent in the Corridor. Treatment focused on adequate cleaning followed by injection with a lime material filler followed by a surface mortar utilizing components similar to the pictorial layers.

After many investigations and tests, numerous questions were answered regarding the pictorial layers and pigments that transformed due to the effects of heat and smoke. With this information, chemical cleaning could commence. A technique known as a "negative cleaning" technique was used in two different applications. The West wall, North and South stela pertained to inscriptions and scenes with raised and sunk relief. The East wall and areas in the West wall, North section, pertained to flat painted scenes. The same materials, tools, and general time-frame were employed in both treatments.

The inscriptions and scenes underwent a background treatment using a light gel poultice over Japanese paper. Once the process was complete, the poultice was removed along with the soot and dirt that had previously covered the background. The cleaning of the background created a contrast with the inscriptions and scenes creating a clearer visual spectrum.

Figure 17 – The Northern Stella and East wall sections after gentle chemical cleaning

The tomb contained both vaulted (as in the Transverse Hall) and flat ceilings. Due to the poor and unsafe conditions of the ceiling, a method of reinforcement was necessary.

Temporary protection was installed to protect the conservators while the ceiling was monitored and a plan was developed to secure it. Loads and activity above the tomb were factors that led to the fragmentation and separation of rock layer in the tomb ceilings, especially in areas containing chalk and calcite veins.

The first step in the plan of securing the ceiling involved a geological study performed by Dr. Ayman Hamed who is a professor at the Engineering Geological Department in Helwan University. ARCE Luxor provided the survey maps that recorded the levels above the tomb. With the information attained, reinforcement could be implemented. The ARCE Luxor Conservation Manager together with Master Mason Frank Helmholz, began to install the reinforcement at selected points. The reinforcement consisted of drilling up to sound strata and installing all-tread stainless steel rods secured by epoxy. A washer would then be placed over the rod contacting a small area of the ceiling. An acorn nut would then keep the washer in place. In this manner, the sound limestone strata would support the roof section while at the same time the reinforcement would be non-intrusive and virtually aesthetically invisible.

In conjunction with the rock bolt system and to further stabilize the ceiling, focus on filling cracks and securing loose fragments took place. The first step involved removal of dust and dirt from the cracks. Transparent tubes were then placed in the cracks to introduce grouting material. Thin cracks were injected with epoxy resin. Mortar was then utilized to provide a finished surface. With both systems securely in place, the ceilings are structurally stable.

Figure 18 – Transverse Hall ceiling before reinforcement

Figure 19 – The grouting in the ceiling .

Figure 20 – Transverse Hall ceiling after reinforcement

The condition of the Corridor suffered from the same characteristics of deterioration as other areas within the tomb. All of the conservation activities performed in the Transvers Hall from ARCE Luxor's documentation system, consolidation, re-adhesion, crack grouting, patching, securing and cleaning was performed. As a result of gentile chemical cleaning of the North wall, several previously undocumented scenes were revealed including several individuals playing instruments.

The Pillared Hall was free of any scenes, inscription or decorations but it also obtained the full ARCE Luxor documentation system. Several structural issues required attention. The two pillars were badly decayed and in a state of disrepair. The conservation team applied grouting and consolidation including carbon fiber rods coupled with installation of original pillar fragments, to return the pillars to their original function. The ceiling also received rock bolt reinforcement where required.

The ceiling and the walls were covered with thick layers of soot and was systematically removed by the conservation team. The team also installed rock masonry along the edges of the shaft so that a safety steel mesh cover could sit level and flat over the opening.

To prepare the tomb for visitation, a flooring and handrail unit was installed in the Transverse Hall complete with solar powered LED lighting. A motion sensor at the entrance automatically switches the tomb lighting on and will turn off the lighting after approximately 10 minutes of absent motion.

Outside of the tomb in the forecourt, the exposed bedrock, due to the clearance operation, required coverage to protect the original stairs and landscape. Quality limestone pavers were placed over a clean sand base that provided not only bedrock protection, but afforded safe access to TT110 and other tombs that shared the forecourt.

Figure 21 – TT 110 forecourt landscape after conservation project