Article: Conservation of Inscribed Sandstone Fragments at Luxor Temple in Egypt
Author(s): Hiroko Kariya
Source: Objects Specialty Group Postprints, Volume Twenty-One, 2014
Pages: 283-303
Editor: Suzanne Davis, with Kari Dodson and Emily Hamilton
ISSN (print version) 2169-379X
ISSN (online version) 2169-1290
© 2014 by The American Institute for Conservation of Historic & Artistic Works,
1156 15th Street NW, Suite 320, Washington, DC 20005. (202) 452-9545
www.conservation-us.org

Objects Specialty Group Postprints is published annually by the Objects Specialty Group (OSG) of the American Institute for Conservation of Historic & Artistic Works (AIC). It is a conference proceedings volume consisting of papers presented in the OSG sessions at AIC Annual Meetings.

Under a licensing agreement, individual authors retain copyright to their work and extend publications rights to the American Institute for Conservation.

This paper is published in the Objects Specialty Group Postprints, Volume Twenty-One, 2014. It has been edited for clarity and content. The paper was peer-reviewed by two content area specialists and was revised based on these anonymous reviews. Responsibility for the methods and materials presented herein, however, rests solely with the author(s), whose article should not be considered an official statement of the OSG or the AIC.
CONSERVATION OF INSCRIBED SANDSTONE FRAGMENTS AT LUXOR TEMPLE IN EGYPT

CASE STUDY
HIROKO KARIYA

ABSTRACT
Since 1995, the Epigraphic Survey of the Oriental Institute, University of Chicago, known as Chicago House has been carrying out conservation of inscribed sandstone fragments in Luxor Temple, Egypt.

Over the last 18 years, the project went through various phases in order to meet the most immediate needs on site. The original focus on documentation, treatment, and condition monitoring of about 2000 registered fragments quickly evolved to include emergency protection of additional 40,000 unstudied, inscribed fragments. After the emergency protection of the fragments was achieved, the project focus shifted to site management including stabilization of temple walls by reconstruction and providing public access to the collection by creation of an open-air museum. This article discusses challenges such as managing a massive amount of semiportable artifacts with limited resources, balancing protection with public access and working with a community heavily reliant on the tourist industry. In addition, it includes the ongoing impact of Egypt’s 2011 revolution on the community surrounding the site as well as on our conservation approach.

1. INTRODUCTION
1.1 LUXOR TEMPLE FRAGMENTS
The city of Luxor, known as Thebes (pharaonic Waset) in ancient times, is located approximately 700 km south of Cairo. Luxor Temple, on the east bank of the Nile, was mainly built during the reigns of Amenhotep III, Tutankhamen, and Ramses II in the 14th and the 13th centuries BCE. The temple was constructed from large sandstone blocks decorated mainly in painted raised relief, as shown in figure 1. Traces of historical defacement, restoration, and alteration are present on some blocks. When the temple was reduced to a quarry for building materials in late antiquity, the blocks were cut to small sizes for reuse in the foundations of mud brick superstructures in the immediate vicinity. The latest of these were occupied into the late 19th century. In the 1880s and 1890s Georges Daressy, working for the Egyptian Service d’Antiquités, cleared all post-antique stratigraphy down to the ancient levels. When this happened, the ancient fragments faced reuse again, this time as fill in the construction of the Nile “corniche” (or embankment road); however, the inscribed fragments discovered during excavations by the Egyptian Antiquities Organization along the Avenue of the Sphinxes in front of the temple during the 1950s and 1960s were retained by them in the Luxor Temple precinct. Following excavation, these fragments were stored directly on damp ground contaminated with soluble salts (fig. 2).

1.2 EPIGRAPHIC SURVEY
In the late 1970s and throughout the 1980s, the fragments were studied by Chicago House, which collected and documented about 2000 inscribed fragments and established their original provenance within the Temple and sites elsewhere. They were registered and moved onto nine “mastabas” (or platforms) with damp-proof courses created using a bituminous membrane to resist the capillary rise of the ground water. These platforms were purpose-built for long-term storage of fragments in the
Fig. 1. Original sandstone blocks in intact wall (Courtesy of Hiroko Kariya)

Fig. 2. Sandstone fragments after excavation (Courtesy of Lanny Bell)
southeast corner of Luxor Temple. This main storage area came to be known as the Luxor Temple “blockyard.”

1.3 SANDSTONE

According to XRD carried out in 1998 by the Engineering Center for Archaeology and Environment, Cairo University, the sandstone is composed of mainly quartz with traces of clay minerals such as kaolinite, goethite, albite, and oligoclase.

Although the specific provenance of the fragments has not been determined through petrological study, historically comparable sandstone in ancient Thebes has been studied and identified as originating from Gebel el-Silsila, located some 40 km north of Aswan along the Nile Valley. This so-called Nubian sandstone was widely employed as a building material in Upper Egypt (or southern Egypt) from the middle of the 18th Dynasty (1539–1295 BCE), including many buildings in Luxor such as Karnak Temple and Medinet Habu. The sandstone at Luxor Temple was probably procured from this quarry.

1.4 INSCRIPTION MATERIALS

The sandstone blocks are mostly carved in raised relief on surfaces perpendicular to the natural sedimentary strata of the stone. Many carved surfaces are finished with a thin fine gypsum (calcium sulfate) preparatory layer for subsequent painting. There are traces of coarse gypsum mortar and original architectural features such as holes for dove-tail clamps on uninscribed surfaces (and sometimes on inscribed surfaces from reuse).

The original gypsum preparatory layer has minor traces of quartz and calcium carbonate impurity, whereas a thin layer applied over the original paint for ancient restoration or reuse is often found to be a mixture of calcium sulfate and calcium carbonate, common in later periods.

Traces of pigments and/or a preparatory layer are preserved on about a third of the registered fragments. Pigments were identified by the author using a polarizing light microscope and/or microchemical spot tests in Luxor. These pigments include Egyptian blue (calcium copper silicate), red ochre (iron oxide), and yellow ochre (iron oxide), all commonly used pigments in ancient Egypt. They are often found mixed with calcium sulfate with minor quartz inclusions to create a lighter shade; for example, calcium sulfate is mixed with Egyptian blue to create light blue; with red ochre to create a reddish skin color; and with yellow to create a yellowish skin color. In addition, a greenish blue pigment consists of Egyptian blue and yellow ochre.

2. DETERIORATION PHENOMENA

Limited analysis to identify the substrate and determine deterioration causes as well as the effectiveness of treatment was carried out by the Engineering Center for Archaeology and Environment, Cairo University. The majority of the study on materials and deterioration was based on visual examination under low magnification on site as well as simple “low-tech” testing such as microchemical spot tests and/or use of indication strips. Long-term monitoring provided the most useful and realistic information to determine treatment and protection approaches.

2.1 GRANULAR DISINTEGRATION

The main problem of the fragments is granular disintegration due to the loss of natural binding media such as clay minerals, especially along vulnerable bedding planes. An early stage of granular disintegration can be seen in figure 3, while figure 4 shows advanced disintegration of the same block.
This deterioration can be accelerated by the movement of soluble salts due to environmental fluctuation as the fragments were exposed to the ambient outdoor environment since excavation. This could result in the total disintegration of the stone over time.

2.2 SOLUBLE SALTS

While reused in foundations, many fragments were exposed to contamination by human and animal organic waste as well as the natural salinity of the local soil. It is reported that rapid population growth in the Luxor area and the construction of the Aswan High dam in 1970 accelerated the contamination of local ground water. It should also be noted that sandstone samples from Gebel el-Silsila
contained chloride and nitrate ions; thus, soluble salts in fragments could originate from not only the burial environment but also from the original quarry site.

An XRD analysis indicated that a sample collected from deteriorated stone contained a mixture of sodium chloride (halite) and/or sodium nitrate. A total of 96% of samples collected from 107 fragments detected chloride, nitrate, or sulfate ions by qualitative and/or semiquantitative tests (microchemical spot tests and/or indicator strips). Both chloride and nitrate were more common than sulfate salts. Many samples, especially those collected from actively deteriorating stone, contained a higher quantity of chloride than nitrate ions. It is difficult to determine the behavior of a mixture of salts as they have a wide range of equilibrium relative humidities.

Significant concentrations of soluble salts were detected at least 9 cm below the surface of deteriorated stone, even though the physical disruption may only affect a few millimeters of the surface. Samples collected at 1.5 cm intervals from a single drilled hole (from decayed uninscribed fragments) showed that the concentration of chloride ions is high, extending almost equally through the depth to at least 9 cm, whereas that of nitrate ions decreases as the depth increases (for an unidentified reason).

2.3 OTHER TYPES OF DETERIORATION

In addition to the deterioration described earlier, deteriorated surfaces can be pitted by minor occasional rain. Pigments are friable due to loss of binding media. Some paint layer(s) are flaking off from the preparatory layer or the stone surface due to lack of adhesion. Emergency consolidation of inscribed surfaces, possibly with diluted polyvinyl acetate emulsion, carried out in the 1970s caused surface darkening due to exposure to the outdoor environment. In addition, since this consolidant did not deeply penetrate to bond the deteriorated area and relatively intact core, it caused surface exfoliation as the consolidant shrunk. Other types of deterioration were also present, such as staining from nearby construction sites and cracking and breaking due to improper handling and poor storage conditions.

3. CONSERVATION PROJECT

The current conservation work was started as a four-year funded project in 1995 by my predecessor, John Stewart. I joined the team in 1996 and have been working every year since then (between 3 weeks and 4.5 months per season) except for 2003 when the second Iraq war started.

3.1 TREATMENT OF REGISTERED FRAGMENTS

The principal objective of this initial conservation project was the stabilization of about 200 of the most seriously deteriorating fragments. These were selected from the 2000 registered fragments. The most effective methods were identified through testing of potentially appropriate conservation materials on site. The project also included documentation, monitoring, and protection of the remaining 1800-registered fragments.

3.1.1 Stone Consolidant

After limited analysis, discussions with conservators working in Luxor, satisfactory results from the 1986–88 treatment, and various field tests including application methods, curing time, environmental condition for application, etc., the inorganic consolidant tetraethoxysilane (TEOS) or Wacker OH (and later Wacker OH100) was selected for use in consolidation of the sandstone fragments. It provides proper strength with minimal or no darkening, desirable penetration, retreatability, and chemical and physical compatibility and stability in outdoor environments. It was also locally available.

Wacker OH is a stone strengthener based on tetraethoxysilane with a neutral catalyst (dibutyltindilaurate). It is a one-component ready-to-use system and does not contain water repellent. Wacker OH comes as a 75% solution in acetone and methyl ethyl ketone (MEK). Later, the formula was changed to “solvent-free” (or “straight”) ethyl silicate and sold as Wacker OH100 (or SILRES BS OH 100.)
TEOS reacts with atmospheric humidity as well as moisture within stone pores. It releases alcohol and forms silicic acid gel, which eventually converts into silicon dioxide ($\text{SiO}_2$).

$$\text{Si(OCH}_3\text{CH}_3)_4 + 4\text{H}_2\text{O} \rightarrow \text{Si(OH)}_4 + 4\text{CH}_3\text{CH}_2\text{OH}$$
$$\text{Si(OH)}_4 \rightarrow \text{SiO}_2 + 2\text{H}_2\text{O}$$

Specific environmental conditions are required during application and curing to achieve optimum results. The environmental conditions recommended for application by the manufacturer are as follows: temperatures between 10 and 20°C (50–68°F) and the relative humidity (RH) above 40%. It requires approximately 2–3 weeks to cure, depending on prevailing environmental conditions. Repeated treatment may be required on severely deteriorated surfaces, in 3–4 week intervals (or longer as it is observed that TEOS could stay hygroscopic for months after curing.)

3.1.2 Application and Curing

Chicago House’s field season usually takes place between mid-October and mid-April. Annual environmental conditions in the shade in Luxor range from 6 to 56°C (mean 26°C) with relative humidity between 0 and 87% (mean 33%). These conditions are often outside of the recommended range of application and curing of the consolidant. As the climate is generally unfavorable for the use of the consolidant outdoors for most of the year (except for a few early morning hours between December and February), a simple microclimate environment was created to maximize treatment time.

A microclimate “tent” for movable fragments was built over an unfinished storage platform filled with sand (used as a sandbox to support uneven fragments). The tent (approximately 6 m (l) × 1 m (d) × 1.35 m (h)) was constructed from a wooden frame (later replaced by an aluminum frame) covered with cotton-backed plastic sheeting (with the cotton side facing out). Figure 5 shows a drawing of the tent’s construction.

The interior of the tent was divided into three sections using plastic sheeting. Water may be sprayed in the tent to raise RH days before treatment if necessary. In the sandbox, selected fragments were placed (over a polyethylene isolating sheet) with the surface to be treated facing up to permit maximum penetration of the consolidant. In most cases, only one face was treated at a time.

![Diagram](image-url)
After testing various application methods including pipet-dripping, spraying, brushing, immersing, and capillary absorption, the consolidant was generally drip-fed, using disposable polyethylene pipettes onto deteriorated stone surfaces until fully saturated. In the case of severely deteriorated surfaces, dripping the consolidant could cause surface loss or pitting; thus, it could only be fed into the margins of the decayed area by capillary absorption.

Each treated fragment was covered with multiple layers of dry newspaper as separation from the slightly damp cotton sheet placed above. Exposure and transfer of newsprint ink to the consolidant was tested before usage to confirm no dissolution of the ink. These layers provide sufficient moisture for the consolidant’s chemical reaction, without mobilizing soluble salts within the stone. The fragment was then covered with a plastic sheet (not tightly sealed). The RH level of the environment of treated fragments was carefully maintained between 40 and 60%.

The consolidation was carried out within one section of the tent at a time. Once completed, the section was closed to reduce evaporation and contain solvent fumes within it. The solvent’s fume concentration around treatment sites was measured using self-indicating dosimeters for MEK, one of the components in Wacker OH. On the basis of this measurement, access to the treatment areas was restricted by personal communication as well as strategically placed signs and ropes.

During curing, distilled water was occasionally sprayed in the tent and/or the cotton sheet cover. After about 3 weeks, the covers on the fragments were removed. After one additional week, the tent was opened to ventilate for a few days. The condition of the fragments was then examined and recorded. Temperature and RH in the tent were recorded using a small digital hygro-thermometer (and later datalogger) and entered in the database described in detail below.

This treatment method provided the most simple and efficient design for treatment of portable irregular fragments. This method maximized the space and time available by minimizing handling fragments, and effectively contained solvent fumes. Two tents were constructed in the blockyard. About 50 fragments can be treated in one tent depending on their size. One cycle of the treatment takes about 4 weeks including microclimate preparation, documentation, transportation and setup of fragments, and curing time.

In the case of consolidation of immobile stone such as large blocks and wall fragments in situ, treated surfaces were first covered with plastic sheets that were perforated in areas corresponding to the treated areas. This was followed by application of cotton sheets lightly dampened with distilled water. The perforated plastic sheet allowed for the movement of water vapor from the sheet to the treated surface of the stone, but prevented direct contact. The cotton sheets were further covered with a solid plastic sheet to prevent rapid drying and inhibit the rapid evaporation of the consolidant. The entire surface area was then draped with a canvas sheet as a sunshade.

These fabric sheets and membranes were held in place on the wall by wooden battens fastened into modern wall joints by means of removable plastic screw plugs. Figure 6 shows a drawing of the microclimate set up for treatment of standing walls.

### 3.1.3 Desalination

The behavior of specific soluble salts in the fragments in a given environment will have an important bearing on their future stability. Because treated fragments must remain in the uncontrolled ambient climatic conditions of Luxor Temple, it is likely that consolidation will only retard the deterioration process, unless fragments can be effectively desalinated (Bradley and Hanna 1986). The presence of soluble salts in the stone may also affect the curing properties of the consolidant. One study showed that Wacker OH does not form a continuous film over salt crystals (Berry and Price 1994). Another study suggests that consolidation should be carried out only if followed by desalination because the consolidation could accelerate salt efflorescence formation (Miller 1992); however, at least in the case of Luxor Temple fragments, salt efflorescence was rarely caused by the consolidation and curing process.
Desalination testing was carried out by the author. Most sample fragments (including both treated and untreated pieces) that were desalinated by immersion or poulticing with various materials appeared to have promoted or activated movement of soluble salts and, thus, resulted in more deterioration than undesalinated fragments. After monitoring desalinated and undesalinated fragments, it was decided desalination would be performed only on limited numbers of fragments because it is difficult to effectively desalinate fragments. Partial or incomplete desalination appeared to promote salt activation. It is also difficult to protect pigments and a preparatory ground layer during desalination. With limited facilities and materials, it is not realistic to plan desalination of a large number of fragments. Instead, the condition of the treated fragments is annually examined and recorded. Desalination was performed on a small number of fragments with continuous salt deterioration and fragments with past or present salt damage that were to be reconstructed on temple walls (as it would be difficult to access them once reconstructed.)

3.1.4 Treatment Results

About 79% of consolidated surfaces showed improvement. At least 12.5% of fragments remained in the same condition (or show no or negligible improvement) after treatment and 8.5% of the treated surfaces continued to deteriorate after a short period of time despite treatment.

The consolidant was not always applied in a single cycle of treatment (one application cycle.) Approximately 49% of treated fragments required retreatment; 44% required second or third applications; and 5% required more than four applications of the consolidant. If retreatment was not carried out in a
reasonable period, deterioration resumed. Because the treatment requires about 4 weeks, it sometimes took several seasons for completion of treatment for one fragment, especially if multiple applications were required.

There was no distinction in stone type between successful and unsuccessful cases of the treatment according to visual examination. Also, there was no difference in the environmental conditions (outside the treatment tents) during treatment and curing. Furthermore, no significant difference was observed in the content of soluble salts and the initial depth of deterioration. The unsuccessfully treated fragments have, however, larger areas of deterioration (more than 20% of their surface area) when compared to the successfully treated fragments.

Approximately 10% of treated surfaces showed darkening during posttreatment examination. The darkening was not related to any specific stone type. An unfavorable curing environment may be responsible for this problem in part. In most cases, however, darkening disappeared after a year or two. A single excessive application of the consolidant could cause darkening of the stone surface. Darkening seemed to be minimized when the stone was not over saturated. Consequently, it proved better to treat a fragment several times rather than oversaturating the stone at once with a single application of the consolidant.

3.1.5 Database

A database (using the software FileMaker Pro) was developed to facilitate monitoring of the treatment and annual condition assessment (fig. 7).

This database can provide information on various aspects of treatment such as the amount of consolidant applied, its application environment, the number of applications, darkening, changes in posttreatment condition, etc.

3.1.6 Summary

In summary, the consolidation using TEOS significantly improved the condition of most deteriorated fragments in the given environment. The following advantages and disadvantages are noted while using this consolidant on site.

The advantages include physical strengthening, high penetration, minimal or no darkening, chemical and physical compatibility with sandstone, retreatability, ease of use, and local availability. The disadvantages include its slow curing process, possible multiple applications required, difficulty in creating a desirable treatment environment for application and curing, unknown long-term stability.
(especially with the presence of soluble salts), brittleness of bonding between mineral grains, limited strengthening for properties for coarse stone with large pores (large distance between grains), high cost, and toxicity, requiring proper personal protection (which can be uncomfortable in the intense heat). It should be noted that although some fragments were treated in slightly less than ideal conditions, no difference in resulting strength was observed. Importantly, the long-term effectiveness of TEOS is of concern especially if soluble salts remain in the stone; however, the few deteriorated fragments treated in 1986–88 were not desalinated. They were left in an uncontrolled environment. After 25 years, they are still in a largely stable condition. Long-term monitoring of the condition of the collection is necessary to appraise the real efficacy of this particular combination of materials and treatment methods.

3.2 EMERGENCY PROTECTION AND DATA MANAGEMENT

While focusing on the 2,000 registered fragments, we witnessed some unregistered inscribed fragments that were still sitting on the soluble salt contaminated ground completely disintegrating into piles of sand. Also, construction around Luxor Temple uncovered hundreds of fragments that were added to our collection. Consequently, we shifted our goal to emergency protection of tens of thousands of unstudied, inscribed fragments.

We built about 200 additional damp-proof platforms. Because most of the blockyard has never been excavated, platforms were built to be temporary, nonsolid structures. They consist of brick walls filled with sand and topped with a damp-proof course, bricks, and mortar. Some fragile fragments were protected in various temporary shelters such as plastic-lined wooden boxes, shelves, and aluminum frames draped with durable “tent” or “sail” canvas sheets because we are not allowed to keep artifacts under lock and key. Very few fragments still in situ were reburied. More than 40,000 inscribed fragments were moved onto the platforms in the vicinity of the original wall locations whenever possible, as seen in figure 8.

During this process, the fragments were sorted by categories, mainly according to historical periods. Various miscellaneous fragments from the Middle Kingdom (the 20th century BCE) to modern

Fig. 8. After sorting and storing of fragments on damp-proof platforms (Courtesy of W. Ray Johnson)
Islamic times were found among the piles. Some fragments were reconstructed on platforms to promote their comprehension. Designated numbers were given to registered fragments. These were applied to the surface using a durable, permanent outdoor marker, Valve Action Paint Marker, that was selected after testing of various markers. Also, a simple FileMaker Pro inventory database was created to manage the massive quantity of data.

3.3 SITE MANAGEMENT

After emergency protection and general sorting of the fragments, we shifted our goal once again to the structural stabilization of the temple wall, site management, and promotion of public access to the collection.

3.3.1 Reconstruction (Structural Stabilization)

Although the original locations of many fragments were identified, only a small portion of the fragments can be returned to their original place because they do not directly join the remaining walls. Because the middle section of the wall was at ground level before the excavation, it was more accessible in the intervening centuries to people seeking to quarry temple blocks for reuse, and thus these blocks are often missing. Moreover, the ground-level position of these blocks made them most susceptible to deterioration.

In 2004, we were urged to stabilize part of the wall in the Colonnade Hall of Amenhotep III. The result is a unique example of the integration of structural engineering, conservation, masonry work, and Egyptological research. During his annual inspection, a structural engineer, Conor Power, identified the wall as one of two structurally dangerous sites at the temple. As many as 48 fragments originating from this wall were located, stabilized, and used as part of the structural reinforcement of the wall, as shown in this reconstruction drawing (figure 9).

Locally fired bricks and lime mortar were used instead of stone to build the main support; this reduced weight and also enables insertion of any fragments discovered in the future. Figure 10 shows this brick core.

![Reconstruction drawing of the east wall in the Colonnade Hall of Amenhotep III (Courtesy of W. Ray Johnson and Carol Meyer)](image-url)
Fig. 10. Brick core to support unstable wall (Courtesy of W. Ray Johnson)
As hydraulic lime is not locally available in Egypt, lime mortar was mainly used. Proper mixtures were selected by a mason depending on areas of use. The 48 extant fragments, including one small piece to join the wall, were inserted in the brick matrix, whereas the upper section of the brick support was faced with sandstone slabs imitating the original stone blocks (fig. 11). Finally, missing sections between the fragments were compensated with minimal line drawings using acrylic paint (selected after testing). The fragments preserve part of the great Opet Festival river procession inscribed during the reign of Tutankhamun, specifically the great riverine barge of the god Khonsu.

Throughout the project, we trained local staff in tasks such as the proper slaking and preparation of lime mortar. Because we are not allowed to bring any heavy mechanical equipment into the temple, the work was carried out manually, just as in ancient times.

This work served as a prototype for the reconstruction of another wall in the Sun Court of Amenhotep III. As many as 111 fragments (including five newly discovered fragments in 2009) originate from 16 large blocks identified by Chicago House in the 1970s. This wall was structurally stable, but twice as many original fragments were used. Of these, 27 fragments were reconstructed in 1986–88. Reconstruction of an additional 82 fragments was completed in 2010. Reconstruction of the remaining two fragments was purposefully kept for the future because of their location. The fragments preserve a depiction of the great bark of Amun-Re and a pile of offerings set up in the court, flanked by figures of Amenhotep III. The wall also presents examples of historical defacement, restoration and alteration; the bark
was carved by Amenhotep III, hacked by Akhenaten’s agents, restored by Tutankhamun, appropriated by Horemheb (who erased Tutankhamun’s name and added his own), and was finally enlarged by Sety I, who added a restoration inscription.

3.3.2 Open-Air Museum and Site Management

With an increased number of visitors to the temple, another phase of the project began in 2007. Although the blockyard had been closed to the public, we strongly believed that many of the fragments could serve as a great educational tool. Our work focused on providing public access to part of the blockyard in the form of an open-air museum. The central idea of the open-air museum is to create a chronological, art historical, and stylistic chain of examples of inscribed fragments from the Middle Kingdom to modern Islamic times with brief explanatory signs in Arabic and English.

In addition to this educational purpose, the project embodied site-management goals. Because visitors to Luxor Temple generally walk through the narrow north–south axis (especially in the hypostyle hall and antechambers in the south) and back the same way, opening this part of the temple significantly eased the flow of visitors (fig. 12).

Fig. 12. New public access added by open-air museum (Courtesy of Hiroko Kariya)
Before the construction, part of the blockyard was filled with modern rubble and trash. As always, the project began by negotiation with the local authorities. All structures were built to be temporary to allow possible future excavation. A majority of the work was manually conducted as heavy equipment is not allowed within the temple. Non-Egyptologists made the initial selection of the display fragments from among the 40,000. We aimed to select fragments that would capture the eye and imagination of the public; thus, our choices were based on wider considerations than scholarly significance alone. Our director, Dr. W. Ray Johnson, later chose historically and stylistically significant pieces from among this group. During their transportation, fragile surfaces were temporarily protected by facing with tissue and/or fabric and cyclododecane. Some fragment groups were reconstructed on the display platform; however, no fragments were directly mortared. They were dry-set in bricks and mortar fill, thus preventing the mobilization of soluble salts and enabling later insertion of any fragments. Losses were compensated by simple line drawings.

In the open-air museum, 200 m of paved paths were created along 12 thematic platforms on which over 300 fragments are displayed, as seen in figure 13.

In addition to the chronological display, the museum includes a group of fragments to highlight the unique features and conservation issues of the blocks, a rotating display with specific themes, and finally a viewpoint for the site of the Roman tetrastyle. The blocks are illuminated by spotlights every evening, keyed to the overall temple lighting system as the temple opens at night.

This project exemplified the integration of various specialties including conservation, Egyptological or curatorial work, design and collections management, and engineering and masonry construction work. We made every effort to use local resources including manpower and materials. Whenever possible, we trained local workmen and used large amounts of recycled materials for construction. In the interest of sustainability, we felt it was more important to use simple, accessible, low-cost materials and regularly replace them than to use more aesthetic, durable imported materials that might become hard to obtain in the future.

Originally, we struggled to balance protection with public access; however, we found that the paved pathway with its railing was adequate and perhaps even more effective in keeping visitors from straying than any "no entry" signs. In addition, as soon as the fragments were displayed, people started to
pay respect to these long-neglected fragments. This also brought challenges. The more people see value in
the fragments, the more we became responsible for their security. Small portable pieces were braced with
metal straps. We also made a visual inventory list for the temple's inspectors to help them to monitor the
collection.

Early ideas for an audio guide were abandoned after considering the reaction of the local guides
to potential competition with their services. Instead, our director gives the local guides an annual on-site
training, which informs and encourages them to bring their tours. In addition, an online catalogue is
currently being prepared for visitors interested in more detailed information about the site.

4. IMPACT OF REVOLUTION AND ONGOING TURMOIL

In February 2011, the Egyptians overthrew 30 years of dictatorship through revolution. This was
completely unexpected for us. It was the middle of the fieldwork season, and events in Cairo took us by
surprise. Although some missions were evacuated, most Chicago House staff remained working on site
during the entire months of the revolution.

Although southern Egypt, including Luxor, turned out to be relatively peaceful with some minor
incidents, it was a long, uncertain time with a lack of reliable information or sometimes no information
at all. The resignation of Hosni Mubarak did not end the period of uncertainty. Turmoil including
looting and theft of antiquities throughout Egypt continues to date.

4.1 IMPACT OF REVOLUTION

During this period, some of the immediate and direct impacts on missions working in Egypt
included decreased site security, delays in granting work permits due to the constant changes in
government personnel, difficulty of planning work, and lack of basic necessities such as fuel and
electricity. Security was a major consideration to individual foreign staff, host institutions, and funding
sources. We observed the difficulty of planning future, long-term work, retaining professional staff due to
uncertainty of schedules, and the emotional impact on local staff.

Luxor with a population of about 600,000 holds many ancient sites such as Karnak and Luxor
Temples on the east bank and Valley of the Kings, Medinet Habu, and Colossi of Memnon on the west
bank. It has been a UNESCO World Heritage Site since 1979 and its economy largely relies on tourism.
Consequently, Luxor's experience over the past 3 years is somewhat unique even for Egypt. The lack of
tourism could mean reduced resources for site maintenance. This experience urged us to review our site
conservation program. We needed to ensure the sustainability of the site without our presence, especially
at the open-air museum.

4.2 EMERGENCY RESPONSE

In January 2014, I returned Luxor for the first time after the 2013 military take-over. Our assigned
inspector, who was one of many young, enthusiastic people hired after the revolution, was excited about
participating in the maintenance program. He set up three meetings with his colleagues for me. Through
these meetings, I discussed with almost 40 inspectors, including the chief inspector of the temple, common
problems such as the improper behavior of visitors (i.e., climbing monuments, etc.) and site maintenance
challenges such as equipment repairs and trash and weed removal. These problems became more serious
due to lack of maintenance personnel after the revolution. We brainstormed solutions such as public
outreach (training local guides, lectures at local schools, greeting tour groups at entrance, etc.) and
comprehensive signage to reduce improper behavior by visitors (proper visitor conduct signage at entrance,
pictogram signs, etc.), installing physical blocking of access (railings, walls, signs, etc.), and systematic
inspection and collaboration with Chicago House local staff for maintenance. I was open to all suggestions, but tried to keep our final trial program simple, realistic, and low cost.

On the basis of their suggestions, in the 2014 season we installed pictogram signs and replaced some ropes with metal chains that are considered to be more respected by local visitors. I also came up with a trial program for the off-season this year. Although not completely independent from Chicago House, this trial program will lay the foundation for independent off-season maintenance. We stocked some consumable materials such as light bulbs for off-season use. A simple checklist in English and Arabic was provided, which will be used during a regular walk-through by inspectors. If necessary, they will report issues requiring attention to one of two inspectors who volunteered to be point persons. They will then contact Chicago House, which will send local staff to repair or provide replacement material. A suggestion notebook was also provided for noting comments by any temple staff for discussion.

4.3 FUTURE PLAN

Next season, we will review the trial program. Signage indicating proper visitor conduct will be installed at the entrance. Also, a workshop on site sustainability with our inspectors may be proposed. Finally, in the future, I hope to reach a formal agreement on responsibilities between Chicago House and the temple staff, and eventually to shift full responsibilities to the temple staff.

5. CONCLUSIONS

We have been lucky to be able to continue the project for 18 years. We tried to meet the needs of the project and the interests of available funding sources. For a project like this, it is important to be flexible to meet any unexpected needs on site. Utilizing local resources is a major factor in our success. It is not only cost effective but also helps us build mutual trust and strong cooperative relationships with the community and local professionals. Increasing public access and education promotes understanding and respect for the site as well as its artifacts. This was one of the most significant outcomes of the project.

Finally, the 2011 revolution (and ongoing turmoil) was a wake-up call. We are still uncertain and adjusting our work as the situation changes; however, the revolution and Egypt's transformation consistently reminds us of the importance of a systematic, practical, and sustainable site management program.

ACKNOWLEDGMENTS

The project would not have been possible without the support of many dedicated organizations and staff including W. R. Johnson, Director of Chicago House, Ministry of State for Antiquities (former Supreme Council of Antiquities, Egypt), American Research Center in Egypt (ARCE), USAID Egypt, World Monuments Fund (Robert W. Wilson Challenge to Conserve Our Heritage Grant). Also, Chicago House staff and workmen including Tina DiCerbo, Nan Ray, John Stewart, Conor Power, Yarko Kobylecky, Sue Lezon, Margaret De Jong, Brett McClain, Ellie Smith, Dany Roy, Frank Helmholz, Harold Hays, Siska Genbrugge, Sylvia Schweri, Safi Ouri, Samir Gundy, and James Heidel.

NOTE

2. To identify the range of RH, white salt crystals typically found on fragments (containing chloride and nitrate) were sampled from five fragments. A small amount of the samples was exposed to microclimate with RH adjusted at approximately 20–30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100%. The samples were monitored to determine their dissolution RH. After a few days, it was observed that one sample was dissolved above 70%, two above 80% and two above 90%. This indicates that the common white salt crystals may be mobilized at RH above 70%.

3. In 2011, 14 million tourists came to Egypt and about 9.4 million in 2013 (many to the Red Sea only). In 2011, Egypt obtained approximately $18 billion from tourism revenue which is 12% of GDP. By 2013, the share of tourism in GDP dropped to $5.9 billion. About 12.5% of national employment relies on tourism, and this is much higher in Luxor. (sources: Middle East Institute; BBC News; Al Ahram; The Guardian)

4. The number of temple staff significantly changed since the revolution. As of March 2014, in Luxor Temple, there are 64 inspectors (including over 30 hired post-revolution after a long-term hiring freeze as a result of protest by temporary staff); 38 guards (there used to be 65 guards, now reduced by attrition); approximately 20–25 conservators; about 10 cleaners (day shift only).

REFERENCES


FURTHER READING


**SOURCES OF MATERIALS**

**ACR, SR-002 SmartReader 2 T/RH Logger**
Herzog/Wheeler & Associates
2183 Summit Avenue
St. Paul, MN 55105-1051
651-647-1035

**Chloride Test Kit Model PSC-DR Code 4503-DR**
LaMotte Company
802 Washington Avenue, PO Box 329
Chestertown, MD 21620
410-778-3100

**Cyclododecane**
Kremer Pigments Inc.
228 Elizabeth Street
New York, NY 10012
212-219-2394; 800-995-5501
[www.kremerpigments.com](http://www.kremerpigments.com)
Digital MAX-MIN Thermometer/Hygrometer
Preservation Equipment Ltd.
Church Road, Shelfanger, Diss
Norfolk, IP22 2DG, UK
+44 0 1379 647400
www.preservationequipment.com

Dist WP Waterproof Conductivity Meter
Merck Ltd.
Merck House, Poole,
Dorset BH15 1TD, UK
+44 0 1202 669770

Gastek Dosi-tube No. 152D (Methyl Ethyl Ketone)
SKC Ltd, 11 Sunrise Park
Higher Shaftesbury Road
Blandford Forum
Dorset DT1 8ST
+44 0 1258 480188
www.skcltd.com

LaMotte Multi-Range Conductivity Meter (model DA-1)
LaMotte Company
802 Washington Avenue, PO Box 329
Chestertown, MD 21620
410-778-3100

Merckoquant Nitrate Test/Sulphate Test
E Merck
Frankfurter Strasse 250
64293
Darmstadt, Germany
+49 0 6151 72-0
www.emdgroup.com/emd/index.html

Polyethylene Pipet Graduated 5 ML
Sigma-Aldrich Corp
St. Louis, MO
314-771-5765
www.sigmaaldrich.com

Quantab Chloride Test Strips
Hach
P. O. Box 389
Loveland, CO 80539-0389
800-227-4224
www.hach.com
HIROKO KARIYA was trained as an objects conservator at the Conservation Center, Institute of Fine Arts, New York University. She has worked in the Conservation Department, Brooklyn Museum, and other museums in the United States. She has also worked on various archaeological sites including the Athenian Agora in Greece, Kaman-Kalehoyuk in Turkey, Mut Temple, Karnak Temple, and Valley of the Kings in Egypt. She is currently in private practice as an objects conservator working in museums and on archaeological sites. She has been a project conservator for the Epigraphic Survey of the Oriental Institute, University of Chicago in Luxor since 1996. She also works as a consultant at the Qatar National Museum in Doha, the Pennsylvania-Yale-Institute of Fine Arts in Abydos, Egypt, New York University Expedition to Abydos, Egypt, for Waseda University at Abusir in Saqqara Egypt, The Metropolitan Museum of Art and the Michael C. Carlos Museum, Emory University in Malqat, Egypt, and for UNESCO Egypt-Waseda University in the Valley of the Kings, Egypt. Since 2009, she has also worked as a conservator for special projects for Harvard University’s Archaeological Exploration of Sardis, Turkey. Address: 509 Morgan Dr, Lewiston, NY 14092-1105. E-mail: hkariya@aol.com or hkariya8@gmail.com