Site Conservation during the Rescue Excavations

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INTRODUCTION

Zeugma has been affected by a major regional hydroelectric project involving the construction of several dams on the Euphrates River in southeastern Turkey. During the summer of 2000, the reservoir for the Birecik Dam flooded 30 percent of the ancient city of Zeugma and the entire ancient city of Apamea on the opposite bank. The inundation took place in two phases: the first stage (beginning May/June 2000) flooded Area A; the second stage (through the end of October 2000) flooded Area B. Area C was not threatened by inundation.[1] This chapter reports on conservation carried out at Zeugma by the Centro di Conservazione Archeologica–Roma (CCA) from June to October 2000, as well as conservation work carried out on finds and maintenance of the archaeological site of Zeugma in a three-year period following the impoundment of the Birecik Dam.

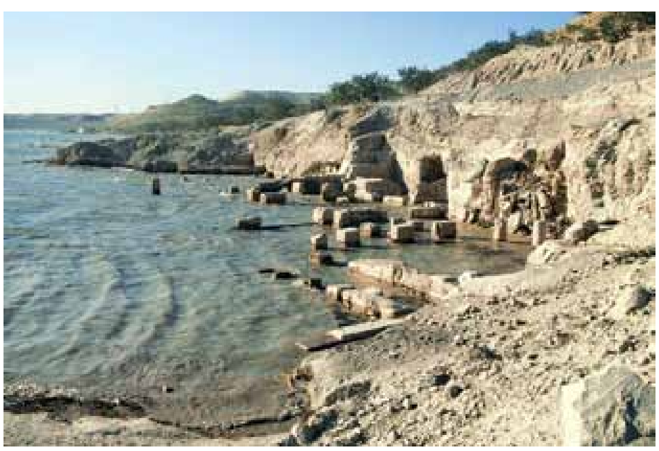

Figure 1. Area A being submerged without protective measures. View to east.

From its very beginning, the rescue project launched and financed by The Packard Humanities Institute (PHI) with the permission of the Turkish Ministry of Culture had three objectives: 1) emergency archaeological investigation; 2) conservation of the site and finds during rescue excavations, as well as the conservation of finds from previous excavations at Zeugma housed in the Gaziantep Museum; 3) publication of scientific results. The principal operatives in this project and their respective responsibilities were as follows: the Southeast Anatolia Project (GAP) was in charge of housing, equipment, local transportation, and logistics; Oxford Archaeology (OA) coordinated excavation on the site;[2] CCA coordinated and carried out all conservation. Less than two weeks into the beginning of the project, 120 archaeologists and 20 conservators were on site and equipped, in large part due to the efficiency of PHI and GAP, and to the approval of the Ministry of Culture. During the rescue project, the water level in the reservoir was rising at a rate of about 20 cm per day, and this meant that participating groups were required to produce agendas and reports on a very limited time scale for discussion with PHI and the Ministry of Culture. Normally, plans were prepared, discussed, modified, approved, and implemented all within the course of one week.

Figure 2. Area A being submerged without protective measures. View to north.

Within an environment organized by GAP, which included local transportation and housing for 250 persons, as well as equipment and infrastructure required for work on the site, an excavation plan was drawn up by archaeologists and the Ministry of Culture. At the same time, CCA supplied personnel, materials, and equipment and set up infrastructure on the archaeological site, including laboratories for emergency field conservation. In cooperation with archaeologists, CCA established a work schedule and communication network to allow for the conservation work to proceed smoothly, and with minimal interference in the ongoing archaeological work (table 1).

By May 2000, conservation at Zeugma was faced with the following set of circumstances: 1) 15 percent of the city would be flooded by the beginning of July (Area A); 2) another 15 percent would be submerged between the end of July and the end of September (Area B), with a strip of land along the new shoreline subject to a continuous 3-m fluctuation in water level per the daily operational necessities of the dam; 3) the remaining 70 percent of the city

	New strategy approved by the Turkish Ministry of Culture	Previous system
Coordination	All operations of conservation, restoration, and protection are coordinated by a single entity (CCA)	Separate groups act independently
Master plan	Master plan designed to treat both previously excavated materials (Area A) and new materials excavated prior to inundation (Area B)	No master plan
Purpose	Purpose of conservation plan directed to protect finds and structures and to facilitate study, publication, and presentation to the public	Sporadic cleaning and restoration carried out only to serve artifact study
Approach	On-the-spot conservation of finds and structures, regardless of classification, during the rescue campaign, with a focus on preservation of the archaeological site; specific criteria for detachment of mosaics and painted plaster developed, regarding: fragility, feasibility of protection in situ, rate of rising water, opinion of the Ministry of Culture	Rapid and systematic detachment of mosaics and painted plaster resulting in the destruction of original structures and stratigraphy
Documentation	Systematic documentation of all activities and treatments	Documentation poor to non-existent
Maintenance	Monitoring and maintenance of all parts of the site, excavated or not; respect for and protection of all original structures left in situ, with hierarchical distinctions of importance based solely on fragility	All nondetached elements of previously excavated areas of the site (Area A) abandoned to floodwaters without protection
Museum support	Direct material and technical support for the Gaziantep Museum for conservation, storage and display of finds	No cooperation with the Gaziantep Museum in these areas
Training	Use of the project for conservation training	No training program
Labor	Maintenance of a high international profile in the composition of staff, with a focus on the inclusion of Turkish restorers already working at Zeugma	Separate groups had a distinct national character

Table 1.

would be unthreatened, but unguarded and susceptible to looting. In addition, in urgent need of conservation were some 4,000 small finds, 100 architectural elements, 700 m^2 of mosaic pavements, and 250 m^2 of painted wall plaster. These items had been removed from Area A and stored, in some cases outside and exposed to the elements, at the Gaziantep Museum during excavations by other archaeologists prior to the PHI rescue campaign of 2000 (fig. 5). By the time the PHI rescue project began in May 2000, excavated structures left in situ by this previous work were beyond salvation from the floodwaters, and they were left to inundation without any protective coatings or backfilling (figs. 1–4). As for the detachment of the 700 m^2 of mosaics prior to May 2000, this had been performed without systematic documentation, inventory, or written reporting and without the aid of professional personnel, but rather was done by untrained laborers employing haphazard methods. After detachment, some mosaics had been stacked outdoors in the courtyard of the Gaziantep Museum. During these operations, many mosaics were severely damaged, and some parts were lost altogether (figs. 5–6).

Figure 3. Area A being submerged without protective measures.

Figure 4. Area A being submerged without protective measures.

THE CONSERVATION PROJECT

The CCA conservation plan for the PHI rescue project that was approved by the Turkish Ministry of Culture was conceived to replace the previous practice of engaging in many uncoordinated, small-scale restoration treatments with a global strategy based on principles of preventive conservation. A preliminary analysis of the situation at Zeugma in May 2000 made clear that Area A and the parts of it that had already been excavated were too close to inundation to merit intervention and that all efforts were better concentrated on Area B and previously excavated finds in need of urgent consolidation and stabilization.

Figure 5. Mosaics stored under tarps outside at the Gaziantep Museum, prior to the PHI rescue project.

In brief, options for rescuing Area B from the waters of the Birecik reservoir in 2000 can be distilled into three basic scenarios: 1) no new excavation, but rather improvement of site burial conditions advised by topographical survey and subsurface prospection, especially near visible archaeological structures in the landscape; 2) excavation and systematic removal of as much archaeological material as possible in the time allowed; 3) a mixed program of geophysics, archaeology, and conservation coordinated between specialists in these fields, with protective coatings and backfilling applied to excavated structures prior to inundation, including recovery and conservation of small finds and limited recovery of mosaics and painted wall plaster. Delaying the inundation schedule was not an option, given the region's need for hydroelectric power and the long warning period leading up to the dam's completion, which had passed without strong public outcry or organized response by the scientific community.[3]

At Zeugma, the inundated part of the site has now been preserved for posterity beneath the silt at the bottom of the Birecik reservoir. The life span of the dam is estimated at 100 years,[4] after which time the artificial lake will be so clogged with debris that the power station will be unable to function. If the lake is ever drained, then the flooded zone of Zeugma can be reclaimed by future archaeologists and conservators who will no doubt be equipped with knowledge and technology superior to ours. Given this fact, the first scenario would have forgone further hasty excavation in favor of consolidating the site exactly as it had been found by the PHI rescue project in May 2000, including the unprotected trenches exposed in Area A by previous excavations. This approach is consistent with thermodynamic principles governing the decay of materials: where there is hygrometric stability, materials decay at an extremely slow rate. In the case of buried archaeological sites, after a period of relatively rapid transformation after deposition and burial, structures and objects tend to reach an equilibrium that can allow for preservation over millennia.[5] This holds true for exposed sites and for sites under water (e.g., the case of Baiae on the Bay of Naples). Consideration of this is also consistent with the recommendations of the International Committee for the Conservation of Mosaics (ICCM), which state that "*the fundamental premise of the preservation of mosaics is conservation in situ and/or its context.*"[6]

Figure 6. An uninventoried mosaic fragment removed from Zeugma prior to the PHI rescue project, showing deterioration, cracking, and staining.

On the other hand, Zeugma had achieved such a high profile in the media by May 2000 due to coverage of the threat to the archaeological site in newspapers like *Sabah* and the *New York Times*, the public outcry for immediate archaeological intervention was overwhelming.[7] In this context, the first scenario, even if ethically most prudent, risked perception as an insufficient means to save Zeugma, and possibly even as an abandonment of the site. Nor was the contrasting course of action offered by the second scenario a tolerable one, because of earlier work in Area A conducted without systematic documentation, site protection, and finds conservation. In the end, the third scenario offered a meaningful and feasible compromise between the urgency to excavate and the obligation to preserve the site in its entirety for posterity.

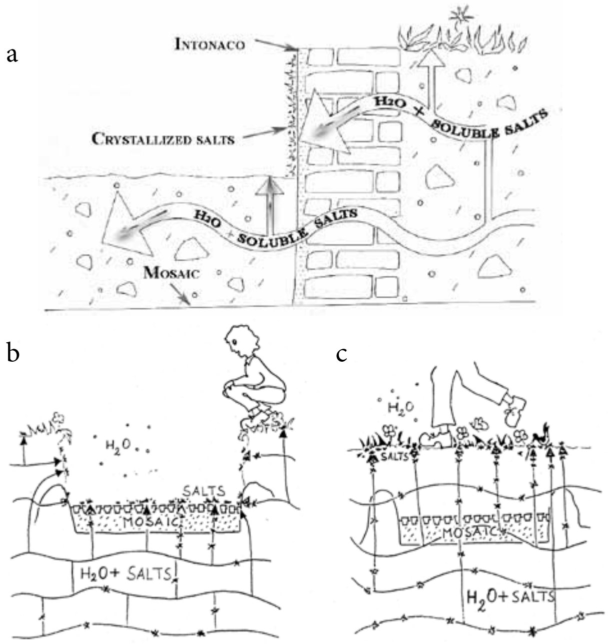

Figure 7. (a–c). The process of soluble salt migration and crystallization on the artifact surface (drawing by A. Costanzi Cobau, CCA).

Thus it was decided to carry out archaeological investigation in order to understand and document parts of Area B — a choice determined by the rate of the rising water, the limited time available for excavation, and the time required for subsequent protection and reburial, as well as accessibility to zones of excavation requiring protection. Starting from the ethical premise of preserving as much as possible in situ, removal operations were extended to all small finds, structures found in precarious condition, and structures unable to be preserved in situ as determined by the Ministry of Culture.

METHODS AND APPROACH

With the problem of the rising water level and principles of minimum intervention in mind, conservation treatments in 2000 were always the simplest and most efficient available in order to achieve the best result in the least amount of time. Simple preventive conservation measures for finds were performed directly by the archaeologists, with on-the-spot support from conservation staff. Treatments of greater complexity were carried out by conservators.

Trench supervisors acted as an interface between the conservators and the archaeologists through a continuous exchange of technical information and planning. Conservators produced weekly work plans for the archaeologists in order to facilitate timing between the archaeological and conservation activities. These plans were based on predictions from the dam administrators about the rate of rising water in the reservoir and estimates for time required for conservation, protection, and reburial.

Figure 8. Shaded work areas to mitigate crystallization of salts on artifact surfaces.

As a rule, in brief, conservation efforts were focused on the following objectives:

- Assist archaeologists during excavation in order to limit, as much as possible, mechanical and thermo-hygrometric stress on finds and structures; facilitate archaeological documentation of structures by archaeologists with on-the-spot cleaning.
- Remove materials threatened with immediate destruction from the site, including in some cases structural elements like mosaics.
- Reinforce archaeological structures to be left in situ using consolidation and contact protection; restore the original landscape before inundation in order to create a stable thermo-hygrometric and water-resistant environment.
- Implement a maintenance program for the so-called "fluctuation zone" along the shoreline of the new reservoir — an area constantly battered by waves.
- Restore everything excavated and removed from the site both prior to and during the PHI rescue project.

ASSISTANCE TO ARCHAEOLOGISTS DURING EXCAVATION

Excavation and Cleaning

In their rescue work on the site, archaeologists were given technical advice about how to prevent damage to surfaces and objects during their work. With temperatures ranging between 40° and 50° C, newly uncovered structures and finds were threatened by rapid evaporation, which often leads to damaging crystallization of soluble salts. This causes loss of surface layers and micro-structural damage through capillary cracks, as well as the formation of insoluble deposits that obstruct visibility of the object surface (fig. 7 a–c). Work areas were shaded to mitigate this phenomenon (fig. 8). In the case of mosaics and painted wall plaster, archaeologists were instructed to leave a 10-cm

Figure 9. Layer of original soil left on the surface of mosaics and painted plaster.

Figure 12. Cleaning performed with soft plastic brushes, synthetic sponges, a 2 percent solution of NeoDesogen in water.

Figure 10. Cleaning performed with a 2 percent solution of NeoDesogen in water and a vacuum cleaner to remove liquids.

layer of the original earth on the object. This protective earth layer was removed by conservators with soft plastic brushes, synthetic sponges, a 2 percent solution of NeoDesogen in water, and a vacuum cleaner for liquids (figs. 9–12). Cleaning was carried out with a high ratio of person to object surface in order to reduce time of exposure of untreated surfaces to heat and air, and to prevent the formation of insoluble layers on surfaces (fig. 13).

In the case of painted wall plaster, vaporized water applied with hand-held sprayers was used to soften the layer of protective earth, which was prone to rapid drying by exposure to air and high ambient temperatures. The removal of the protective earth layer was accomplished with scalpels up to the final layer in direct contact with the original painted surface. After complete removal of the protective earth layer, drying of the original painted surface was controlled by the application of tissue paper wetted with water to serve as a safe repository on which remaining soluble salts crystallize (fig. 14).

Figure 11. Cleaning performed with soft plastic brushes, synthetic sponges, and a 2 percent solution of NeoDesogen in water.

Figure 13. Cleaning carried out by a large team in order to reduce the time of artifact exposure to heat and dry air. Trench 11, **M23**.

Figure 14. Wet tissue paper applied to painted plaster as a deterrent to damaging soluble salts.

The proper treatment of these surfaces immediately following excavation prevented the unnecessary formation of unsoluble deposits. As a result, original colors were not blurred by dust or deposits, and graffiti and other details were clearly recognizable. This method permitted more accurate documentation and interpretation of the archaeological information contained in these artifacts.

Figure 15. Preparing the inscribed stele of Antiochus I (SS1) *for a latex cast.*

Documentation

After cleaning, documentation was carried out with drawing, photography, and video, in both traditional and digital formats. All mosaics and painted wall plaster were recorded at 1:1 scale by direct contact with polyethylene sheets. For the mosaics, the 1:1 drawings were combined with photographic documentation to develop base maps in AutoCAD, and these were used to maintain records of mosaic conditions and treatments performed. Graffiti were recorded with latex casts (figs. 15–17). In all, 2,000 slides, 2,500 digital images, 12 hours of video, 250 m^2 of tracings, 160 AutoCAD drawings, and 25 latex casts were created.

Figure 16. Adding a latex cast to the inscribed stele of Antiochus I (SS1).

Figure 17. Removing a latex cast from a graffito on painted plaster.

Figure 18. Block-lift for large iron objects in preparation.

REMOVAL OF FINDS AND MOSAICS FROM THE SITE

An important component of the PHI rescue project was the removal of archaeological materials from the site that, because of their precarious condition or the opinion of the Ministry of Culture, could not remain in situ. As a result, thousands of small finds, mostly in ceramic, bronze, iron, glass, and organic materials (ivory, wood, bone, etc.), were recovered. As is generally known, most of these items suffer from dramatic microclimatic changes when passed from damp conditions of burial to a hot and dry open-air environment. Furthermore, the conservation process is often complicated by archaeological needs for drawing, photography, and documentation, which often require objects to remain in one place for prolonged periods of time. If this involves exposure to direct sunlight, one can expect negative effects for damp objects, such as loss of surface, deformation, and cracks in organic materials like ivory and bone.

Figure 19. Block-lift for large iron objects in preparation.

The conservation methods and materials used during the PHI rescue project of 2000 were determined by the type and condition of artifact recovered, as well as the particular stage of an artifact between excavation, transport, storage and display. The main goal of first-aid for small finds on the site was the prevention of damage to objects from changes in atmosphere and transport to the conservation laboratory. These operations called for a great amount of coordination between conservators and archaeologists. Treatments were applied by conservators, or, when possible, by archaeologists who had been instructed about proper techniques and materials. Direct exposure to bright sunlight was avoided by storing the recovered objects in ready-made geo-textile bags. Iron and bronze objects were stored in zip-lock polyethylene plastic bags with holes punched in them to permit microclimatic conditions to slowly migrate between atmospheric states. Holes were necessary to avoid the formation of condensation inside the bags. Punched plastic bags were stored inside the aforementioned geo-textile bags in order to avoid exposure to direct sunlight.

Figure 20. Conservation lab for treatment of finds.

In the case of large or fragile objects, a block-lift was used by the conservation team (figs. 18–19). This entailed the removal of the artifact in a semi-excavated state, with the original soil still surrounding it. In the case of compact, fairly humid soil conditions, use of a flat and rigid board inserted under the object was sufficient, followed by the stabilization of object and soil with the application of transparent plastic foil or aluminum foil. Layers with debris from destroyed buildings were often encountered at Zeugma, and this meant the discovery of objects within loose and fragile soils with a high rubble content. In these cases, the object to be recovered was first partially excavated and then protected with transparent foil. The

Figure 21. Restoration of a mosaic removed from the site in one of the PHI mosaic laboratories built at the Gaziantep Museum.

foil covering was then encased in a block of polyurethane foam rigid enough to be lifted safely after the foam had set. For every block-lift, a recovery record sheet was filled out to keep track of all materials used. This was necessary for identifying materials that might have come into direct contact with the artifact, thereby potentially interfering with further archaeological inquiry or conservation treatment. Furthermore, a hand-drawn sketch was made to record the exact position of all lifted fragments.

A total of 4,000 finds and 160 m^2 of mosaics were removed from the site. All artifacts were moved to the finds store on a daily basis for data processing and further conservation treatment. They were then stored in controlled and monitored conditions.[8] Due to the enormous number of finds (for example, 1,200 metal objects and 200 worked stones), the conservation of finds required eight months (fig. 20). All detached mosaics were immediately taken to the laboratory and restored (fig. 21). Of everything that was removed from the site, nothing was left unfinished from the standpoint of conservation.

PROTECTION OF STRUCTURES LEFT IN SITU AND REBURIAL OF THE EXCAVATED AREAS

For work at Zeugma in Area B during the PHI rescue project, in deciding whether to leave a structure in situ or remove it, the primary consideration was the prospect for the object's successful protection and reburial before inundation. Before examining details of how this was carried out, we should first focus on risks involved for structures in the passage from an excavated state of exposure to a state of long-term submersion. At Zeugma, the initial phase of inundation was severe and characterized by extreme thermo-hygrometric instability, in the course of which the mechanical (wave action) and thermo-hygrometric (soaking with water) stresses affecting the archaeological structures were very great. This was followed rather dramatically by a much calmer state, where thermo-hygrometric stability was virtually total and the mechanical action of the waves virtually nonexistent.

The initial state of inundation was fortunately very rapid, but it was still capable of destroying archaeological structures through wave action, which produced holes, washed away original materials, and caused structures to collapse from rapid soaking. The subsequent phase, after submersion, was less problematic from the standpoint of conservation, because a stable environment was once again established, although this time with all materials saturated with water. Given the water density and the thickness of the materials used for reburial of the excavated structures before inundation, thermal variations were reduced to a few degrees centigrade between seasonal changes, and there is obviously no hygrometric variation. Subsurface water movement also has little influence on the flooded city, since the effect of the average flow of 500 m^3/s through the dam is spread throughout the entire reservoir — an area of approximately 40,000 m^2 — resulting in a nominal subsurface current of 1.25 cm/s. Moreover, this current is

Figure 22. Nora, Sardinia. Floor mosaics protected in situ with mortar in the 1970s by the Superintendency of Sassari.

Figure 23. Edging of a lacuna on a mosaic on site.

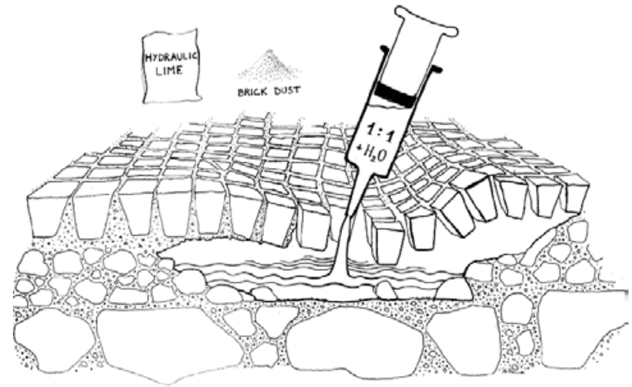

Figure 25. Procedure for the consolidation of mosaics (A. Costanzi Cobau, CCA).

concentrated in the center of the reservoir, with minimal movement near the shores, with the exception of the reservoir surface, subject to wind conditions.

The so-called fluctuation zone at the reservoir surface is a different matter. This is the point of contact in Area B between the reservoir surface and the buried city, essentially a 1.5-km-long meandering path covering an area of approximately 8,000 m². Here the water rises and falls within a range of 3 m (383–385 masl), dependent upon precipitation and the activity of the hydroelectric dam, and this means that this area, unlike the submerged terrain below it, is constantly threatened by the mechanical stresses of wave action. Everything in this zone would be threatened with total destruction, were it not for a specific plan for protection and maintenance implemented by CCA as a part of the PHI rescue project of 2000.

The solution devised to protect the structures before inundation was as follows:

- Facilitate complete documentation of artifacts in cooperation with archaeologists.
- Consolidate excavated structures where necessary and feasible.
- Apply a removable lime-wash undercoating and a 5-cm-thick protective coating of removable hydraulic mortar to mosaics and painted wall plaster.

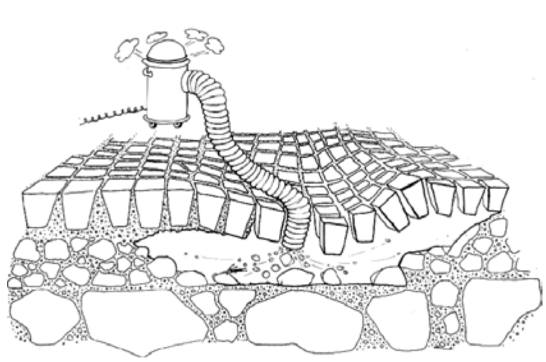

Figure 24. Procedure for the consolidation of mosaics (A. Costanzi Cobau, CCA).

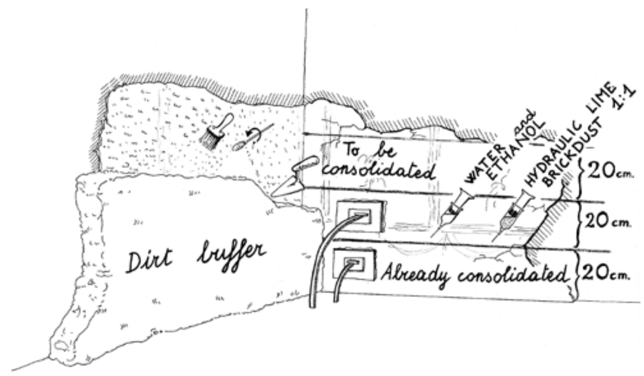

Figure 26. Procedure for the consolidation of painted plaster (A. Costanzi Cobau, CCA).

- Rebury excavated areas under a layer of earth, river pebbles, and stone, with at least a 50-cm-thick covering over the tops of the excavated structures.

The idea to apply a protective coating of hydraulic mortar to mosaics and painted plaster was inspired by many cases in antiquity where coatings of plaster were applied to

Figure 27. Deep grouting of painted plaster with hydraulic lime and brick powder.

Figure 28. A layer of lime-wash applied to the surface of a mosaic. Trench 2, mosaic M14.

Figure 32. Lime-based hydraulic mortar is applied once the lime-wash undercoating has set.

Figure 29. A layer of lime-wash applied to the surface of mosaics and painted plaster.

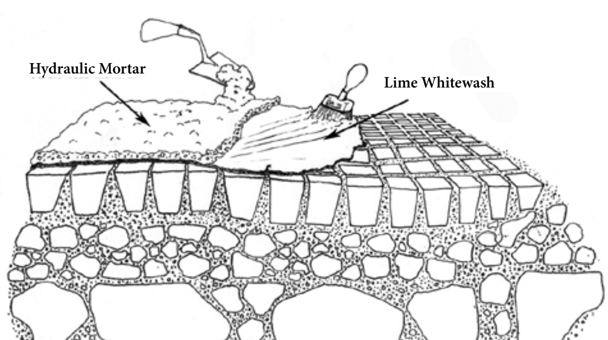

Figure 30. The application of the 5-cm-thick protective layer of hydraulic mortar (A. Costanzi Cobau, CCA).

frescoes and floors for reasons of health (epidemics), ideology (censorship), or style (interior redecoration). The CCA has been involved in the removal of some of these coatings, which are often lime-based in their composition, and in every case we have found the surfaces beneath in pristine condition.[9] Modern proof of the efficiency of this method as a protective measure has come from analysis of a similar coating applied in the late 1970s to 300 m^2 of mosaics at Nora, Sardinia (fig. 22).[10] When the protective coating was removed twenty-five years after application, the mosaics beneath appeared just as they had earlier. Another example of the successful application of this method is the protection of Phoenician funeral mosaics in Porto Torres, Sardinia, in 1994 by the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) for the Soprintendenza Archeologica di Sassari. At Zeugma, the choice of ingredients for the protective coatings was determined by proof of high resistance, outstanding mechanical and hydraulic qualities, long-term durability, and complete chemical and physical compatibility with the original surfaces.

Consolidation of Mosaics and Painted Plaster

Before applying the protective coating over mosaic tesserae, it was necessary to consolidate unstable areas of a pavement. This was accomplished with infiltrations of

Figure 31. Lime-based hydraulic mortar is applied once the lime-wash undercoating has set.

Figure 33. Lime-based hydraulic mortar is applied once the lime-wash undercoating has set.

Figure 34. Lime-based hydraulic mortar is applied once the lime-wash undercoating has set.

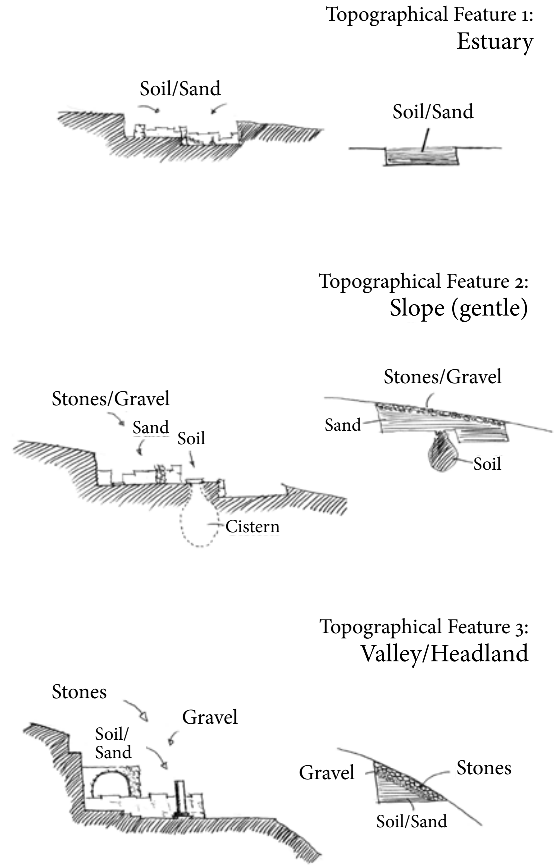

Figure 35. Specifications for layering of ingredients during reburial, according to terrain.

hydraulic lime composed of sifted stone dust, brick dust, and Lafarge hydraulic lime (ratio 1:1). This operation was performed to affix loose tesserae to the original bedding layer and to consolidate the edges of lacunae (figs. 23–25).

In the case of painted wall plaster in imminent danger of crumbling, temporary props were built. Areas at risk were secured with cotton gauze linings applied with high-concentration acrylic resin (Acryloid in acetone, 15 percent), and exposed areas were consolidated. Where layers of painted plaster had separated, injections with hydraulic mortar made with sifted brick dust and Lafarge hydraulic lime (ratio 1:1) were used for consolidation. Lacunae and edges were also reinforced with hydraulic mortar made of stone dust and applied with spatulas. This involved the mechanical removal of accumulations of dirt and roots along edges and in lacunae using scalpels and a vacuum. This was followed by the edging of borders and lacunae with a lime-based mortar made of Lafarge hydraulic lime, slaked lime, sifted brick dust, and limestone dust in a ratio of 0.5:0.5:1:1 (figs. 26–27).

Surface Protection Prior to Reburial

A coating of lime-wash was brushed directly onto the cleaned and consolidated surface of mosaics and painted plaster. This coating had the double function of further consolidating the artifact surface and acting as a buffer between the original surface and subsequent layers of protection, thereby making the latter easier to remove in the future (figs. 28–29). After this lime-wash had dried and set, the protective layer was applied. This was a 5-cm-thick layer of hydraulic mortar composed of Lafarge hydraulic lime, slaked lime, brick powder, and stone dust in a ratio of 0.5:0.5:1.5:0.5 (fig. 30). This layer was extensively worked to obtain full adhesion to the surface beneath it and to improve the carbonation process of the mixture's aerial components (figs. 31–34). This "sacrificial" coating was designed to protect the artifact from mechanical stresses of the reservoir's fluctuation zone. Moreover, the hydraulic properties of the mortar slow the saturation process and prevent an abrupt soaking. In addition, the hydraulic properties of this mortar induce a continuous hardening during submersion and therefore an improved resistance of the material to mechanical stress over time.

REBURIAL OF THE EXCAVATED AREAS

It was clear from the very beginning of the project that all trenches had to be backfilled to minimize the impact of the inundation on the archaeological site. Corresponding with the conclusion of archaeological work on the site in

Figure 36. A protective layer of soil is put in direct contact with archaeological features already coated with protective mortar.

October 2000, trenches were backfilled following a strategy designed in accordance with time allowed prior to inundation, as well as matters of the availability of machinery, materials, labor, and site logistics. The techniques and materials used during the reburial were selected in view of the availability of materials in the region, the conservation needs of the archaeological remains left in situ, and the topographic situations of the trenches.

Ancient architectural materials and techniques found at Zeugma fall into one of four categories: large cut-stone masonry, constructions of stone pillars alternating with loose stone and mud infill, walls of mud-brick with a high gravel aggregate, and poor-quality mortared-rubble constructions.[11] Even though some of these structures had been founded directly on bedrock, the nature of the construction techniques rendered all of them susceptible to extreme danger if exposed to direct wave action.

Figure 37. A protective layer of soil is put in direct contact with archaeological features already coated with protective mortar.

These observations led to the following considerations:

- Excavated structures would be most susceptible to damage during inundation.
- Soil coverage alone would not offer sufficient protection for excavated structures exposed to wave action.
- Excavated structures needed a careful "packaging" to prevent the dissolution of original earthen and lime mortars when passed from a humid, open-air environment to a saturated state.

It was therefore decided to build up a differential covering, moving from fine and soft materials applied in direct contact with the archaeological remains to bigger and heavier materials exposed to the wave action. The materials used were soil, sand, gravel, and stones. The size (diameter) of these materials was as follows: soil from 0–5 mm with some major inclusions, sand 0.5–5 mm, gravel 10–30 mm, stones 50–200 mm. The exact sequence of build-up was determined by the topographical features of the individual "trench environments" (fig. 35). In gently descending valleys, a simple soil and sand filling was sufficient, but trenches on steeper ground required heavier sealing materials. Here, soil and sand were still used to pack the structures tightly to prevent damage, and gravel and stones were used above this to hold the underfilling in place and resist the wave action (figs. 36–37).

Figure 38. Once the archeological remains are covered, the reburial is completed with gravel and stones.

The soil and sand placed in direct contact with archaeological features was humidified and compressed in order to avoid shrinkage when soaked with water. Special care was taken to fill all cisterns and rock-cut rooms to prevent cave-ins and settling. These operations were carried out by hand using wheelbarrows and shovels. Remaining backfill operations were carried out with machinery wherever possible. Where terrain was difficult, materials were brought as close as possible to the trenches by mechanized transport, and then distributed by manpower. Once all the structures in the trenches were covered with soil and sand, the backfill was sealed with gravel and stones. Generally, we aimed for a covering of at least 50 cm above the top of the soil fill. In the case of gentle slopes, the gravel and the stones were mixed, while on steep hillsides the stones were distributed as a separate layer above the gravel. This had the effect of a natural filter, whereby the larger elements held the smaller particles in place and kept them from being washed away (figs. 38–39). A total area of 8,700 m^2 was reburied, covering 18 excavation areas.[12] The volume of materials used for reburial was 10,500 m^3, and of this, 6,300 m^3 (equivalent to 630 truckloads of sand, pebbles, and stone) was brought in from off site.

POSTEXCAVATION SITE PROTECTION AND SHORELINE MAINTENANCE

A few months after excavation and backfilling operations ended, it became clear that specific areas of the new shoreline were succumbing to erosion in the fluctuation zone. Winds channeled by the Euphrates River basin build up once they reach the reservoir, and the energy built up by the waves is often great enough to displace the heavy protective covering of gravel. Furthermore, wave action continued to disturb unexcavated zones along the shoreline, and this

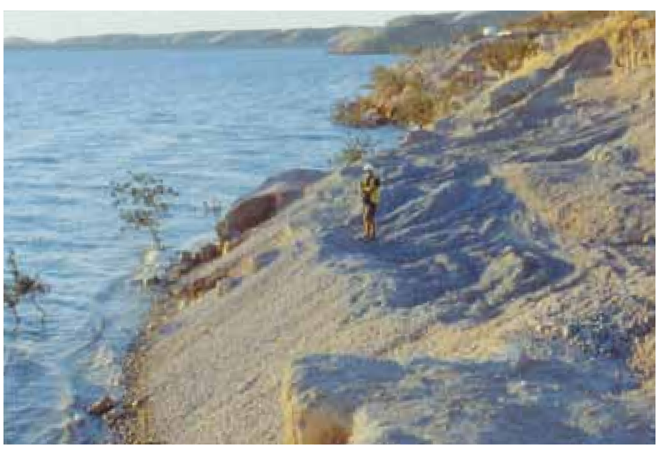

Figure 39. Once the archeological remains were covered, the reburial was completed with gravel and stones.

Figure 40. Trench 6, view to northwest, where reburial was not implemented and the structures were inundated with only hydraulic mortar for protection.

Figure 41. Tall waves now splash against the shoreline on a windy day.

led to the recovery, but more often loss, of archaeological remains brought to the surface. In some cases, walls and floors protected with hydraulic coatings during the project were exposed, but these have proven to withstand the conditions of the fluctuation zone. Newly exposed structures did not fare so well, and these had little or no resistance to erosion on the shoreline. Walls collapsed and floors were undermined. It was clear that further protective measures were necessary to minimize damage to the newly exposed archaeological materials in the fluctuation zone (fig. 41).

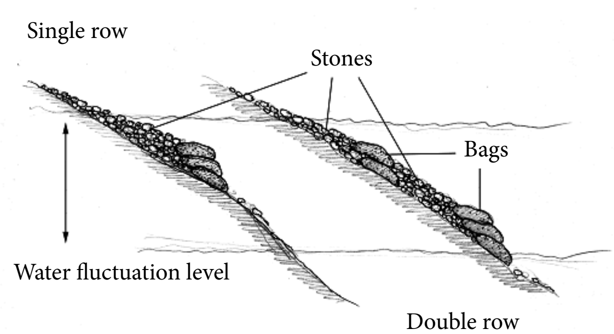

Figure 42. Schemes for the two types of shoreline protection according to the topography of the shoreline.

To improve the efficiency of the protective system put in place immediately following the excavations in October 2000, the following measures were implemented. Rows of woven plastic (nylon) bags filled with gravel (10–30 mm diameter) were arranged parallel to the shoreline. These were stacked according to the slope of the shoreline, between two and four bags high. The nylon bags do not last well outdoors because they are susceptible to UV radiation, so the uppermost rows of bags were filled with gravel mixed with cement. Behind this barrier, heavy stones (100–200 mm diameter) were filled in up to the high-water mark observed during storm conditions. Where the shoreline configuration allowed it, a double row of bags was arranged 2–5 m apart. The space between the rows of bags was filled

Figure 43. Positioning the bags filled with gravel.

with pebbles (figs. 42–43). After one month it was clear that the material of the bags was insufficient as a protective device. The plastic deteriorated quickly, spilling the fill into the water and polluting the environment. It was therefore decided to employ locally available, biodegradable canvas sacks. The life-span of these canvas sacks was intended to correspond to the time required for the gravel/cement mixture inside to dry and take its final form.

These protective measures were carried out with local manpower, using tractors equipped with dump-load trailers, under the supervision of conservation professionals. A total of 5,000 bags and 85 truckloads of pebbles (equivalent to 850 m^3) were used (fig. 44).

Maintenance of the fluctuation zone in the first year after excavation required 600 working days plus materials and machinery. The total cost was $20,000 USD, or $2.5 USD per square meter per year. These data were confirmed during the second year of maintenance in 2001–2002. Overall, CCA conducted maintenance of the shoreline consistent with the above description from October 2000 until March 2004 with permission of the Gaziantep Museum and the Ministry of Culture (the Ministry of Culture and Tourism after November 2003). Management of all areas of the site has now reverted to the Gaziantep Museum and the Ministry of Culture and Tourism.

Figure 44. Filling in the terrain behind the bags with stones.

THE FUTURE OF SITE CONSERVATION AT ZEUGMA

At the time of writing the site of Zeugma is not protected, and the following variable conditions can be observed at different areas of the site:

- Immediate rescue activity is needed (archaeological investigation plus conservation).
- Consolidation/protection of known archaeological structures in situ is required.
- Stabilization/protection of the shoreline is needed.
- No action is necessary where an equilibrium has been achieved on the new shoreline.

Future attempts at site conservation should bear the following issues in mind:

- Seasonal fluctuations in the water level of the reservoir.
- Determinants of the size and impact of waves, such as wind direction and speed and shoreline conditions.
- The geological formation of the shoreline.
- The makeup of the archaeological remains.
- The effect of the protective measures described above.

A three-step process for planning a conservation strategy for the archaeological site in the fluctuation zone is recommended:

1. Documentation and Analysis

- Study and publication of the information collected during the excavation campaign of 2000 in order to understand the nature of the remaining archaeology at risk. The publication of this volume fulfills this for the PHI rescue project. The publication of final excavation results for areas managed by the Gaziantep Museum, the University of Nantes, and the ZIG group will complete this requirement.
- A plan for comprehensive mapping of the site.
- Rescue investigation and conservation of those sections of the shoreline under immediate threat of destruction.

2. Interpretation

The plan should be subject to principles and constraints defined by a **Cultural Project**, and policies for the presentation and cultural use of the site should be clearly defined. Objectives of a **Cultural Project** should be:

- To conserve and transmit to the future the landscape and the archaeological remains.

- To disseminate historical-scientific information about the ancient city and the history of the site (e.g., by way of an on-site museum and tours of visible ruins on the site).
- To document and disseminate information on events surrounding the inundation, rescue, and conservation of the archaeological site in 2000.
- To integrate a plan to protect the shoreline with a plan for the presentation of the site to the public.

3. Protection

With the implementation of the above-mentioned programs for mapping, excavation, documentation, and publication, as well as the definition of the priorities of a Cultural Project, the technical program for the protection of the site can go forward. Criteria for this are primarily the cost and availability of materials and technical solutions, such as, in the specific case of the shoreline, gabions, geotextiles, gravel and cement-filled canvas sacks, direct infilling with gravel, and off-shore nets.

The general policy applied at Zeugma under the tenure of CCA for the protection and conservation of the landscape and archaeological remains was based on the principles of minimum intervention, progressive action, efficiency, and full reversibility. Any future strategy for the protection of the shoreline should be based on similar principles, with the added knowledge that use of multiple solutions for protection of the shoreline will help to diminish the environmental impact of any one solution. In addition, the strategy should aim for an integrated display of monuments, barriers, and protective devices, tourist paths, an on-site museum, and the natural landscape, including beaches on the shoreline of the artificial lake.

CONCLUSIONS

The PHI rescue project at Zeugma was an enormous challenge for archaeologists and conservators, given the methodological, technical, climatic, and organizational issues involved. The tragedy of the flooding of the ancient city and the enormity of the challenges faced by archaeologists and conservators led to the clear definition of a methodology to guide conservation during the rescue project, and this was based on principles of reversible and preventive conservation of remains in situ wherever feasible. The use of this method at Zeugma has already given rise to discussion, and it will continue to do so in the future. The site-wide conservation program developed and implemented by CCA at Zeugma in 2000 has provided a context for focusing public attention on principles of preventive, reversible conservation of remains in situ. Key to this discussion is the decision, in the context of an emergency rescue excavation with a dramatically limited time frame to preserve the majority of what can be preserved in situ for posterity in an efficient manner, or to concentrate resources on preserving a few select materials by extraction at the expense of the site as a whole. The conservation program at Zeugma in 2000 took the focus off the rescue of individual objects at the expense of the archaeological site, and it pursued an all-inclusive strategy for conservation that involved an integrated plan of protection, training, documentation, respect for the integrity of cultural heritage, and the development of local resources, all with a view to ensuring that the accomplishments of more than three years' work can be sustained and furthered in the future.

NOTES

1. For areas A, B, and C, see Aylward, this volume, and Early 2003, fig. 2.
2. Principal excavations on the site between June and October 2000 were carried out by OA, the Gaziantep Museum, and the University of Nantes, each operating in independent excavation areas, all under the umbrella of the PHI archaeological project. The Zeugma Initiative Group (ZIG) also conducted some excavation late in 2000, independent of all other groups.
3. There were some attempts to bring attention to the problem: e.g., Kennedy 1998, 11–8; Algaze et al. 1994.
4. GAP-RDA 2001, 29.
5. de Guichen 1984.
6. Michaelides 2001.
7. The appeal of Mr. Aykut Tuzcu, editor of the Gaziantep daily paper *Sabah*, was taken up by the *New York Times* in May 2000, and this brought worldwide attention to Zeugma.
8. Becker 1999; Elert and Maekawa 2000; Green 1997; Höpfner 1999.
9. For example, in Rome (Republican houses in the Forum Romanum, basement floors of the Cripta Balbi) and Israel (House of Birds and Fish at Zippori and the Baths on the Sea at Caesarea Maritima).
10. Archaeological Superintendency of Cagliari. The treatment was performed for conservation purposes by Dr. Carlo Tronchetti in the late 1970s.
11. See the descriptions of masonry in the chapter by Tobin in this volume.
12. This included all of the excavation areas reported on in this volume, in addition to trenches managed by the Gaziantep Museum (3 and 8) and the University of Nantes (6 and 14), although backfilling operations in Trench 6 were not completed (fig. 40).

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