Tomb 825: A Case Study in Planning for Restoration of a Selected Monument in Petra

Zaki Aslan and May Shaer
Department of Antiquities of Jordan and GTZ (German Technical Cooperation)

Abstract

Due to natural processes of weathering, the rock-hewn facades of Petra are deteriorating rapidly. Water, salt and the presence of limonite within the sandstone layers are the major causes for this deterioration. In this study, the weathering forms have been noted and classified in a methodology which would be further implemented for the conservation of the Petra monuments.

The methodology implemented in the conservation of Tomb 825 includes investigative steps that are necessary for the understanding of the monument in terms of its history, architecture and condition, in order to arrive at the appropriate execution measures. The investigation process consists of recording and documentation of the facade, architectural investigation and condition assessment, all of which lead to the establishment of the intervention plan.

Introduction

Tomb 825 (Tomb of Fourteen Graves) has been chosen as the first monument to undergo conservation measures, as part of the ongoing project which aims at establishing a Conservation and Restoration Center in Petra. The choice of this specific tomb, which had been chiseled out of the natural sandstone, is primarily due to the fact that it is representative of most of the monuments of Petra in terms of construction methods as well as types of weathering forms. Thus, a comprehensive recording of this monument was done, in addition to an architectural investigation, an assessment of the damages and finally, an establishment of a preliminary restoration concept and plan of action. The construction of a scaffolding in front of the facade made it possible to closely examine the monument and to notice details which would have been otherwise overlooked, and hence to carry out studies necessary for understanding the history of this monument and to plan for the execution of the restoration.

1. Recording and Documentation

Although documentation on archaeological excavations, traditional architecture and monuments in Petra has often been conducted, a well defined methodology for the selection of the appropriate scope, level and recording methods had never been established. As part of the main objectives of the preservation project in Petra, developing such a methodology for recording and documenting the monuments is at the heart of the conservation process. The conservation process includes providing aid, facilitating and expediting the initial studies, master planning, project management, maintenance and monitoring of the historic monuments and places. Moreover, it is known to include certain steps. First we need to investigate in order to achieve the necessary understanding which will allow us to choose among appropriate options for action.
For heritage recording, both traditional and digital tools and techniques are used in Petra. In fact, different methods can be combined, based on the required scope of recording, and, vector and raster heritage records are produced accordingly. Table 1 illustrates these methods.

In order to achieve a comprehensive investigation, accuracy in recording and the close examination of the monument are necessary. Thus, after the reconnaissance survey of Tomb 825, two methods of recording followed. The first method involves the use of the total station with a built-in laser pointer. The total station consists of a long-range EDM Distance Measurement without reflectors (Leica-Wild Dior 3002S), this Distomat is fixed on an electronic theodolite (Wild T 1010) connected on-line to a Hewlett Packard OmniBook (4000CT) portable computer. The other documentation method used relies on the more traditional way of hand recording. It is very useful when filling in the details that would be tedious to accomplish by using the distance measuring technique. With hand recording, the monument can be closely examined and the “as found” condition documented. Therefore, details of construction, such as stone insertions and tool marks can be analyzed, and also, a comprehensive condition assessment study can be prepared.

2. Architectural Investigation

The Nabataeans implemented two types of building techniques in Petra. The first technique is characterized by the construction of buildings out of quarried sandstone blocks, while in the second technique the Nabataeans carved monuments out of the solid sandstone mountains. The most prominent features which have been constructed by carving are the characteristic tomb facades. As evidenced by one of the unfinished tombs of Petra, the carving of these facades was done from top to bottom, and in such a facade the entablature and capitals were first completed while the inside of the rock was hollowed out, and, afterwards the stone-cutters proceeded downwards in carving the facade (Browning 1982:165). According to Hammond (1973:77), before the facades were shaped, the mountain rock was first cut and smoothly dressed, and this was followed by the carving of details. In order to reach the higher areas of the rock for working, the stone carvers either came from above or they had a movable scaffolding. It is possible that as they started from the top, the stone cutters carved a portion of the upper part of the mountain, making a horizontal platform from which they continued carving to the inside. After that, they went down to cut another lower platform and again carved the facade at that level, continuing in this manner until the whole tomb was shaped.

Many parts of the facade have been constructed out of stone insets, especially found along the left side of the monument. It seems that due to the stone’s poor quality in such areas of the facade, it was preferable to insert quarried stone blocks. In order to insert a stone block, a cavity was first created with an area a little bigger than the exact final size needed, and then the moulded stone pieces were inserted and fitted with smaller stone fragments and then covered over with mortar. Moreover, in carving the facades, the Nabataeans used the pointed, toothed and flat chisels, in addition to the axe. The finished surfaces that were produced are characterized by the diagonal dressing of parallel lines.
3. Condition Assessment

3.1 Introduction
Due to natural causes, such as weathering, and earthquakes, the monuments in Petra are rapidly deteriorating. Water can be considered as the major cause for weathering of the facades of Petra where deterioration typically occurs in areas of the rock which have a high water content. This is significantly marked on the lower parts of the facades where water absorption can be enhanced by capillary action, flooding in heavy winter seasons and ground water accumulation in front of the facades. Furthermore, deteriorated areas can be noticed on architectural details and elements where puddles of water can be formed, causing damage to protective cornices, and thus to the facade surfaces underneath. The Nabataeans, however, implemented measures which helped in draining rainwater away from the facade surfaces: of these, we notice that the tops of cornices, pediments and crowsteps were slightly sloped in order to prevent the stagnation of water. Such architectural elements protected some of the plane stone surfaces below and kept them in the relatively good condition that they are today. Nevertheless, due to the lack of maintenance and preservation measures, these elements have now greatly deteriorated where some are washed out, while others are broken or chipped off.

3.2 General Condition of Tomb 825
The weathering forms found on Tomb 825 are representative of the general condition of the Petra facades and monuments. The mapping scheme of the weathering forms of the facade shows that about one third of the stone surface can be considered intact, and, original stone surfaces can be found in protected areas where masons’ tool marks can still be clearly seen. Moreover, the overall state of this monument typically consists of the main weathering forms which vary in type, intensity, location and distribution.

There are two major faults which cut through the facade of Tomb 825: one can be recognized in the middle of the facade from the top part all the way to the lower level, while the other is found along the left corner of the facade. The latter, in fact, forms a channel which enhances water percolation on the facade surface, making the rock on that side very humid and highly moist. As previously mentioned, the Nabataeans were aware of this problem which made the stone material fairly weak. Thus, they avoided carving the forms they designed on that side of the facade, and instead, they used stone insets which completed the facade elements. Moreover, such humid conditions helped in the growth of vegetation and accelerated the weathering of the stone insets and the binding mortar.

On the facade of Tomb 825, backweathering can be noted as a major weathering form, where the stone material is lost parallel to the stone surface. This phenomenon occurs at the lower part of the monument as a result of water flooding and rising damp. It can also be seen along the upper parts of the monument due to the absorption of water in the porous limonite veins that are found in the sandstone material. Actually, the nature of the components of the Petra sandstone is a major inherent problem in the rock. Limonite, in particular, can be considered as a major cause which, because it is highly water absorbent, can lead to more advanced deterioration types. These further develop into backweathering and the formation of alveoli. Furthermore, a high moisture content encourages the evaporation process and the formation of salts below the masonry surface, which along with wind erosion can accelerate alveolar weathering. The problem of surface deterioration is aggravated by the washing out and the
formation of salts in areas where water pockets can form. In fact, stagnant water is the cause for further backweathering and spalling of architectural details.

3.3 Classification Scheme of the Weathering Forms

A) Detachment of Stone Material

2. Flaking: Detachment of small, flat, thin pieces of the outer layers of the masonry surface.
3. Scaling: Detachment of large flat layers of uniform thickness which follow the profile of the masonry surface.
4. Exfoliation: Is the detachment of the outer surface of masonry into thin layers which occurs parallel to the masonry beds, sometimes referred to as the “bedding problem”.

B) Loss of Stone Material

1. Pitting: Presence of small cavities in the non-homogeneous stone surface, which is a result of different rates of erosion of single particles of stone.
2. Alveolar Weathering: Existence of alveoli (cavities) which are created in a honeycomb pattern.
3. Outbreaks: Breaking away of stone pieces or compact fragments in different sizes. They occur due to mechanical causes, vandalism, gunshots, etc.
4. Spalling: Is the breaking away of stone pieces or chunks in the masonry surface due to natural weathering in a localized area.
5. Backweathering: Loss of stone material parallel to the stone surface or profile, and sometimes following the limonite veins.
6. Washouts: Eroded parts of masonry surface of soft sandstone material or sand pockets which are regularly washed and etched by rain.
7. Missing Insets: Original stone insets of the carved facade that have been lost leaving a cavity.

C) Formation of Deposits on the Stone Surface

2. Surface Crust: Formation of a hard thin skin which is strongly attached to the masonry surface, due to the leaching out of the internal components of the stone (cementing material, salts or other substances within the stone).
3. Salt Crust: Is a type of a surface crust in the form of a solid layer of colorless or white salt.
4. Vegetation: Growth of plants in joints or cracks of masonry due to a high moisture content.
5. Insectile Colonization: Formation of small nests by insects formed on stone corners or infestations in the sandstone.
8. Paint: Non-original paint or graffiti caused by vandalism or modern reuse.

D) Cracking

1. Crack: identifiable fracture in the stone material which occurs as a result of weathering action such as temperature changes within the stone, they can be divided into two types: 
   a) Slight Cracks: Identifiable narrow slight lines (less than 1.5 mm) of fractures at the stone surface.
   b) Severe Cracks: are cracks that are more than 1.5 mm wide.
2. Joint: A rather plane surface of parting produced by strains imposed on the rock. In a joint there is no displacement of the sides of the fracture. Joints can form under tension or compression produced by the bending or folding of strata strains that are released along fractures.
3. Fault: A fractured surface or zone in the rock, in which one wall of the fracture is displaced relative to the other wall. Faults are produced by stresses in the earth’s crust that either compress or extend rocks and cause them to shear.

E) Deterioration in mortar / plaster

1. Plaster detachment.
2. Mortar disintegration.
3. Mortar infestation due to biogenic growth.

4. Intervention Approach on Facade 825

Three levels of intervention can be implemented according to the priorities of each case. These levels include preservation, restoration and reconstruction. Considering the concept of minimal intervention on the archaeological remains of Petra, major execution work will only be conducted on deteriorated areas of the upper half of the facade to assure the necessary protection. The lower part would be preserved in its “as found” condition without the addition of new elements; this is due to the lack of evidence sometimes, and is an attempt to avoid reconstruction when it does not provide further protection. On the other hand, along the upper parts of the Tomb 825 facade, it would be necessary to introduce new compatible materials in order to be able to repair the deteriorated protective architectural elements and cornices. The treatment of such details would provide protection for the plane surfaces underneath. In particular, the upper cornice should preferably be completed and “reconstructed” in its original form.

The new material which will be introduced would consist of natural raw materials available in the area. Sand, therefore, will be used for compatibility reasons with a silica-based binding material (silica sol). Mortars are being tested in the field to decide on the suitability of their components and proportions, and to observe the long term impact on their appearance and color. On the other hand, consolidants will only be used when architectural details become very friable. Therefore, consolidation techniques are also being tested in the field and include commercially available formulas of ethyl silicates (Wackers and Remmers). The testing of consolidants considers the application mode, as well as their application prior and after
introducing the new mortar. A silica sol based wash is also being considered for stabilizing areas where sanding and flaking take place on the stone material.

Additionally, samples from the monument were used in the laboratory investigations for the determination of stone characteristics that are relevant to weathering. The laboratory investigations targeted the determination of mineral components, compressive strength and porosity characteristics.

4.1 The Execution Plan for Tomb 825

On the basis of each weathering form, a certain appropriate measure is specified according to the intensity of damage. The major interventions include:

- Filling and patching with mortar: This includes patching outbreaks and spalling parts. Such an intervention will be necessary in areas where the stone material is lost. In areas where alveolar weathering takes place, additional stones can be used in the mortar to fill in large areas. Filling with mortar is to be used for closing pits and cavities where water can accumulate, as well as in areas where limonite and detached surfaces are in an advanced state of weathering. This can be considered as a sacrificial layer to prevent further decay. It is to be also used in areas where cracking is encouraging water to precipitate in the stone material and in joints where the original mortar is becoming infested. Additionally, a coping of a mortar layer might be used on the tops of the cornices and other architectural elements for the drainage of water.

- Injection with the new mortar: Injection requires a liquidized type of the same mortar components to ease its application. It will be used to fix detached stone surfaces, particularly, scales and exfoliated masonry layers.

- Consolidation: Sanding and flaking areas of sandstone will require some consolidation. Testing is still being executed to investigate the possibility of using a silica sol based wash alone or with a consolidant. The consolidants might also be used to stabilize the newly applied mortar. However, decisions on whether to apply these consolidants prior or after laying out the new mortar can be taken at a later stage, when the test results are ready.

- Removal/Cleaning of deposits: Removal of deposits includes removal of biogenic and vegetation growth, salt crusts, paint and bird droppings. As well, cleaning includes simpler measures like removal of soil and dust accumulated on top of cornices, as well as salt efflorescence and washouts. Salt extraction might be a necessary action, especially where new mortar is to be added.

- Introduction of new stone insets: Where missing insets of cornices and pediments enhance further damage to the facade, newly cut stone will be introduced in the same original Nabataean construction technique.
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References


