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Towards a Risk Management and Conservation Plan for the Djin Blocks at the World Heritage Site of Petra, Jordan: The Case of Djin Block No. 9

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Cultural heritage is subjected to many pressures and risks. Over the past few years, the use of digital technologies has significantly changed the approaches to cultural heritage documentation for the purpose of condition assessment and conservation. The integration of novel approaches and techniques has permitted a detailed examination and assessment of damage, deterioration due to weathering and erosion, and their mechanisms. This study seeks to contribute to the preservation and conservation of the significant heritage of the so-called Djin Blocks at the World Heritage Site of Petra in Jordan. While these three dimensional cuboid rock-cut monuments have been subject to extensive conservation studies, this is the first time they have been subjected to 3D recording and multispectral photography, with the aim of recording damage caused by the ravages of time.

This study presents the results of the documentation of the case study Djin Block No. 9. A variety of systematic documentation techniques were used, including 3D recording with terrestrial laser scanning (TLS), close-range photogrammetry, multispectral imaging, and thermography records. In addition, pathological studies of the erosion from various causes and an analysis of the effect of weathering on Djin Block No. 9 are performed. Based on this data, the paper presents recommendations for developing risk management and conservation planning of Djin Block No. 9.

KEYWORDS thermography, temperature analysis, sandstone weathering, photogrammetry, 3d laser scanning, photo-modelling, deterioration, Petra, Jordan
Introduction

The sandstone monuments of the World Heritage Site of Petra in Jordan are fragile and face a number of challenging impacts. Anthropogenic and natural factors (flooding, weathering, salt, water content and snow, wind speed and orientation), play a vital role in the deterioration, erosion, and damage process. The vulnerability of these monuments, however, increases due to dissociation or neglect, when neither maintenance nor restoration is undertaken, especially with the absence of documentation, risk management, and conservation plans.

On the other hand, where a significant risk is determined, appropriate action to minimize the risk should be undertaken and a risk mitigation plan should be prepared, through an institutional approach and within the internationally developed frameworks (ICOMOS New Zealand, 2004). Based on the management planning system proposed by Martha Demas (2002), two important elements are necessary in the planning and risk management process: the assessment of values and a physical condition assessment. These form the necessary basic steps before starting the core part of risk assessment.

In order to suggest an effective risk management and conservation plan for the Djin Blocks, using the case study of Djin Block 9 (Figure 1), the aims were to define and clarify:

- The Djin Blocks’ values and cultural significance
- Why we selected Djin Block No. 9 to study
- Approaches and techniques used for the condition assessment of Djin Block No. 9
- The Djin Block No. 9 condition assessment: risk factors, forms, and causes of the deterioration and erosion.

Understanding and assessing the Djin Blocks’ values and cultural significance

Twenty-six cuboid three-dimensional rock-cut structures, called Djin Blocks (after the Arabic word for ‘genie’), stand out mysteriously against the famous rock-cut

![Map showing the location of Djin Block No. 9 in relation to the Siq entrance.](image)
monuments of the World Heritage Site of Petra. They are spread throughout the area, but their value and significance is seldom recognized; the background to these fascinating monuments presents an enigma. Their significance can be defined by the following aspects:

1. *Their location:* Many of these are the first monuments that one sees in the archaeological park. A characteristic complex of three massive Djin Blocks is located in the famous gorge, the *Siq*, which forms the entrance of the city. They form a well-integrated complex, in relation to the surrounding landscape, in the upper white Ordovician sandstone formations along the open streambed (called the *Outer Siq* or *Bab As Siq*) (Figures 1 and 2a).

2. *Their relation with water sources:* Interestingly, the water supplied by aqueducts cross the Necropolises of Petra (the funerary complexes and the three massive Djin Blocks), before reaching the houses of the city centre. This actually reflects how the Nabataeans chose to design their city. One can observe that these Djin Blocks were often built next to water dams, cisterns, and channels. This is very common in Petra, as if a water-burial ritual was adhered to. Coming from higher grounds at the *Outer Siq* entrance, one can observe clay pipes meandering alongside the *Outer Siq* on the northern side. It reaches around the bottom of Djin Block No. 8 and crosses above a small streambed (*wadi*) to reach the floor of Djin Block No. 9, and passes into the channel at the bottom of the northern hill. An open water channel, also coming from the higher region of the *Outer Siq* poured its content into the dam (Figure 1b). The small *wadi* east to Djin Block 9, and above which the clay piping crosses, has a small dam which is fed by the open channel and the watershed from the northern upper regions. The proximity of the Blocks to running water may suggest that they were related to the worship of water, bearer of fertility. This essentially seems to have been a religious and ritual practice that occurs in the surrounding area of the tombs of notables in Petra.

3. *Their function:* The Blocks were not originally constructed tombs, but probably as memorial monuments adjacent to subterranean tombs. The only exception is Block No. 9, which had a tomb carved into the centre of its roof. Their
FIGURE 2a  The complex of three massive Djin blocks located at the entrance of the city (the Siq). Djin Block No. 9 is the first from left.

FIGURE 2b  The top of Djin Block No. 9. It consists of a flat surface, with the centre hollowed out by a rectangular cavity, probably serving as a later grave.

cubic style is possibly part of a tradition originating in the Arabian Peninsula: they may be akin to the Kaaba in Mecca.

4. *Their chronology:* They are believed to be of the earliest Nabataean funerary monuments and possibly date back to the second or early first century bc.
The selection of Djin Block No. 9

We chose Djin Block No. 9 (Figure 2a and b) as a case study because:

1. **Architecture**: This Block has the most elaborate architectural form, features and details, with four façades pointing roughly towards the four geographic quarters.

2. **Scale**: It is the largest of the three Blocks in the Djin Blocks complex.

3. **Material**: It is one of a few monuments carved out of whitish Ordovician sandstone, while most of the monuments inside Petra are carved out of the peach-coloured middle and upper part of the Cambrian sandstone (Akasheh, et al., 2005).

4. **Water setting**: The water features around this Block are extensive; the destruction of the water management system in the immediate vicinity, and the open tomb on top, has led to extensive weathering.

5. **Wind exposure**: Wind has contributed substantially to the weathering process, and the extent of weathering is not the same from all sides. The least affected northern side is protected from wind by a small hill. The western side is the most exposed to the sun and has the highest temperature variation during the day-night cycle.

6. **Prioritization**: This Block was the only item that the Department of Antiquities (Jordan) put forward for the Euromed Heritage programme — which aimed to facilitate contact between cultural promoters of endangered Mediterranean heritage and international investors — on the basis of the monument's significance.

Architectural description of Djin Block No. 9

Djin Block No. 9 is c. 9.8 m high, 5.5 m wide, and 5.5 m deep. The four façades are all similarly carved. The square roof of the monument consists of a flat surface where the centre is hollowed out by a rectangular cavity, probably a later grave (Figure 2b). The main façade, architectural concept, and formation reflects late Hellenistic architecture in its approach and formation (Haddad, 1999). Each of the Block’s four identical façades consists of five main architectural elements (Figure 3). These are:

1. A plain top entablature of rectangular sides.
2. The inset cornice: A rectangular groove in which a row of inset stones were fixed with mortar. The row running around the squared Block from all façades forms a typical late Hellenistic cornice. At the north eastern corner, a stone inset exists, although it does not cover the perimeter of the Block.
3. The plain entablature: Another plain entablature follows, lying on top of a thin torus and a wider fascia.
4. The engaged order unit. This unit is highest in elevation. It consists of inset capitals, curved engaged columns with bases attached to the Block. On each side of the Block there are two engaged columns (of semi-circular section) probably with curved Ionic, late Hellenistic bases. On either side of the corners of the façades a pilaster is carved forming the right-angled corner of the
The Djin Blocks are just a small part of the exhaustive considerations of a World Heritage Site like Petra. However, even a single small-scale monument like the Djin Block No. 9 requires documentation and risk assessment activity. To facilitate this, a detailed documentation, using the latest available technology, was carried out.

The documentation approach involved several techniques linking surface profiling with a 3D terrestrial laser scanner, photogrammetry, thermography, manual engineering surveying, corrected digital photography, as well as a close visual field inspection and observation of the various deterioration forms that plague the monument. The representations of the monument were enhanced with multispectral imaging and thermography to record weathering effects, such as alveolar wind damages, flaking, cracks, and moisture and salt, by applying pathological measurements of erosion. Optical microscopy, portable XRF and laboratory analysis were conducted. Only the XRF was carried out in situ. The test samples for the laboratory analysis were taken from natural rock in the vicinity.

FIGURE 3 The four facades of Djin Block No. 9: (a) west and south; (b) east and north. It is evident that the degree of damage follows the sequence: south (worse affected), east, north, and west (least affected).

Block. These pilasters are attached to quarter engaged columns also with inset capitals on both of its sides, thus enhancing the overall symmetry image.

5. The base unit: It has a stepped formation that adds to the majesty of the monument.

Approaches and techniques used in the condition assessment

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Four different surveying sensors were used for the data acquisition on site:

- **Leica T1800 reflectorless total station.** The standard deviation of a single distance measurement is of about 2–4 mm.
- **TLS medium-range time-of-flight MENSEI GS100;** panoramic field of view of 360° (horizontal) and 60° (vertical), 5000 points per second. This scanner incorporates an internal colour calibrated video camera that has a maximum resolution of 768 × 576 pixels. The standard deviation of a single distance measurement is 6 mm at 100 m.
- **Canon EOS-1Ds Mark III digital camera,** with a full-frame CMOS sensor, resolution of 21 megapixels, and 24 mm focal length.
- **FLIR ThermaCAM B4 camera** to acquire the thermal infrared imagery. It works in the spectral electromagnetic domain of 7.5–13 μm. It has a high thermal sensitivity of 0.10ºC and produces clear noise-free infrared images with a resolution of 320 × 240 pixels. For the purpose of measurement, its wide angle lens (field of view 41º × 31º) was used.

Manual survey served to correct the photographs and reduce camera distortions, which is an important factor for the accurate documentation of the monument.

The result was that the Djin Block No. 9 was photo-textured in 3D (Cabrelles, et al., 2009; Navarro, et al., 2009). The integration of TLS data sets and close-range photogrammetry was applied to yield accurate high resolution photo-realistic models of the Block (Figure 4). Elevations and plans were also obtainable from the combination of photogrammetry and TLS. TLS provides 3D point clouds as well as rough

![FIGURE 4 Photorealistic 3D model of Djin Block No. 9: (a) western and southern sides; (b) northern and eastern sides.](image-url)
photo models that can substantially be improved after draping texture from external high-resolution imagery.

The thermal images were also used to analyse thermal contrast, the behaviour of materials, and alterations, in order to provide further information about the state of the monument. The thermal imagery mostly accentuates the architectural details of surfaces, clearly showing the edges and any damage they may have incurred. It was used to complement analysis after draping the thermal content on to the 3D model (Cabrelles, et al., 2009). Moreover, the thermal information provides an effective way to display the sequential layers of rock as well as the rich ornamentation chisel on the sandstone; this was even enhanced after analysing the 3D thermorealistic model (Figure 5). In comparison, this kind of information hardly exists on the visible image, or the photorealistic model. Thus the benefits of a combination of both sets of imagery, visible and thermal infrared, assists in determining features, alterations, or damage, which are otherwise very difficult to characterize by traditional means. Furthermore, the integration of the imagery to yield 3D photomodels allowed a comprehensive analysis far beyond traditional 2D imagery. The false colour images actually enhanced the interpretation of materials, deteriorations, and damages owing to the juxtapositions of multiple responses of the electromagnetic radiation onto the objects.

Whenever thermal infrared images were taken, supplementary visible images of the same area were captured with a conventional digital camera, for cross-checking. Several representative spots on each side of the monuments were manually selected in order to evaluate the effect of temperature load, extract the temperature, and direct insolation of the Djin Block. In addition, visual inspection was conducted to illustrate diagrams. These are helpful in making appropriate plans for cleaning and consolidating the friable surfaces of the façades.

![View of the western façade of Djin Block No. 9: (a) visible image; (b) thermal image.](image-url)
Mapping of the damage was undertaken using software such as AutoCAD and ArcGIS, combining field observations and photographic images. All the recorded images were draped on to the 3D model. These techniques serve to document with accuracy the surface profile, as well as the architectural characteristics that are still evident. These will also serve as a benchmark for periodic assessment of the state of deterioration.

Finally, a number of consolidants were tested, both in the laboratory and in the field. Four types of consolidants were tested on samples of white Ordovician sandstone, representing the sandstone formation of the Djin Block: Paraloid B72, Funcosil 100, Funcosil 300, and a Tetraethoxy Silane. Apart from the NRA tests, stone cubes were subjected to the salt test in 5 per cent sodium sulphate solution. The consolidants used were Polaroid B72 (Talas – USA) in acetone (5%), Funcosil 100, Funcosil 300, and Tetraethoxy Silane solutions as provided by Reimmers, Germany (Akasheh, et al., 2005).

**Condition assessment: risk factors, forms and causes of deterioration and erosion**

An attempt is made here to identify the types of deterioration and erosion risks, decay, and the probability of its occurrence due to natural and environment factors. However, emphasis is placed on the factors of synergies and interaction between the natural phenomena and the other causes of damage, particularly in the structural material. The results of some environmental indicators were very helpful in correlating weathering of this monument with the various stresses that are responsible for decay and damage. The following are the main risks identified, based on the investigation of the causes of deterioration, decay, damage, and erosion forms.

**Investigation and assessment of the weathering mechanism in relation to stone surface temperature variation**

It was important to evaluate and understand the deterioration and erosion scale in relation to temperature, orientation, and location on the sandstone surface of Djin Block No. 9. The amount and the intensity of sunshine, heating at different times of day, and at different times of year, were examined for the four different orientations using infrared remote sensing techniques (thermal camera). The effect of direct insolation, weathering, and stone surface temperature were studied and analysed to explore the correlation between surface deterioration and thermal stress. This was conducted on each side of the Block, at different times over the day in late spring (29 and 30 April, 2009). The main results were:

1. It is evident that the southern façade is the worse effected, then east, north, and west (least effected) (Figure 3) (Akasheh, et al., 2005; Heinrichs, 2008).
2. The comparison of temperature load and weathering damage does not show any clear correlations. Very severe damage, for example, occurs on both the highly temperature-loaded and low temperature-loaded monuments. Temperature weathering does not the primary cause of the damage on the Block.
3. The north façade, which is always in the shade due to the small cliff behind the monument, has the lowest temperature, while the east façade has the most
stable temperatures. The south façade always has the highest insolation at midday; while the maximum overall temperature variations are seen in the west façade, which means that this façade exhibits the maximum temperature load.

4. It is surprisingly that the north façade does not have the least temperature difference. Perhaps the extent of slight recession damage on the north façade (Akasheh, et al., 2005) is correlated to the fact that less sunlight produces fewer wetting and drying cycles and to the minimum temperature values measured onto its sandstone surfaces. However, the surface of this façade was seen to be wet during April and June 2005, long after the rainy season was over. The exposure to hard sun results in evaporation of water in the rock pores, thus causing salt deposition, with more dramatic results than for the other unexposed façades.

5. We conclude that the main weathering mechanisms are due to water flowing down the façades, capillary rise at the base, and aeolian weathering: these seem to be the main factors for the heavier damage observed on the southern and eastern façades (Figure 6). The heavy solar exposure on the western side is not a major factor in weathering.

**Investigation of the deterioration and erosion using optical microscopic examination and other laboratory tests**

As evidence from the optical microscopic examination and other laboratory tests, the Ordovician sandstones have a relatively high mean porosity, with the highest observed being c. 20 per cent. They are very friable, and in-situ XRF tests indicated high salt content, as expected for heavily weathered stone, especially with the deteriorated lime mortar of the inset stones (Fitzner, 2004; Heinrichs, 2008).
The nature of the sandstone, with its high porosity, the presence of some clay within its matrix, and its infestation with salts, has clearly contributed to deterioration. Using spatial analysis techniques, the elemental distribution of the points was transformed into a grid distribution, from which contour lines for each element could be drawn (Figure 7). The highest concentrations of calcium, for example, are found at the bottom of the monument, possibly due to the down flow of salts during the rainy season, as well as capillary rise due to water pools. Though, clear correlations are observed between weathering damage and water impact in combination with salt loading.

Consolidants substantially improve the physical properties of the stone, reducing the porosity and enhancing compressibility strength. From the compatibility ratings for each of the four types of consolidants, it appears that the most suitable is Funcosil 100 (Akasheh, et al., 2005).

**Assessment and diagnosis of the structural threats**

The visible assessment of physical condition is an integral and important part of the risk assessment.

Assessment and diagnosis of the structure suggests:

1. The corrosion of the pressurized (clay pipe) and open channel water management systems surrounding the Djin Block has contributed to the weathering of the monument. In addition, erosion from wind, rainwater and salt threatens to destroy this monument and the other two Djin Blocks in this complex (Figure 2).

2. The roof surface in general is in good condition. However, some scaling and exfoliation was observed, edges were rounded and pitted, and a recess to hold the structure cover was heavily rounded, thus allowing for water runoff along
the façade surface (Figure 2b). Given that the grave is open, it is liable to collect water during rainfall, which results in long contact times between water and sandstone, with more water impregnation into the rock. The outcome is more salt dissolution and re-deposition of salts on the surfaces.

3. All the façades of the upper entablature are subjected to heavy water runoff, thus causing edge rounding and some exfoliation along the bedding planes of the rock (almost horizontal).

4. The groove below the entablature that runs around the four façades has lost most of its inset masonry cornice, and most of the remaining inset sandstone is rounded and sandy, or exfoliated. Originally, the Blocks of the inset cornice were held in place with mortar which was used to attach the inset stones, but due to heavy water down flow, the mortar has dissolved, washed down the façade, and re-deposited as scales. The dissolved mortar has played a major role by interacting with downward flowing water to exacerbate the situation. Naturally the impregnation of the rock fabric with mortar salts is extensive.

5. In the area where the four pilasters lie, heavy alveolar weathering — especially in the east and south façades — has occurred (Figures 3, 4, and 5). This has often caused a loss of architectural detail, as well as deep pits, holes, and cracks (mostly in the horizontal direction).

6. The lower part of the façades is heavily weathered, especially the architectural features at the base. This heavy weathering at the bottom of façades is very common in Petra; the collection of rainwater in pools, combined with inadequate drainage, leads to the capillary rise of humidity in the façades. This has a detrimental result, with heavy salt efflorescence.

7. A deep and wide crack, with holes, lies along the bedding plane in the lower part of the Block. This crack runs from the east side to the south, and then to the west, although it does not show clearly on the north façade (Figure 4). This is a serious weakness that may cause the whole Block to slide and topple. This type of problem has occurred at Petra during serious flash floods. An earthquake could also have serious damaging effects.

Towards a risk management and conservation plan for the Djin Blocks

The development of a risk assessment and a related management methodology is considered a preliminary step to feed into the overall management plan of the property (UNESCO, 2010). The development of policies, and a long-term plan of action, requires coordination at the administrative level, and in Jordan legal, technical, organizational, and financial aspects need to be considered. A successful management and conservation plan needs to use a multi-disciplinary approach, and should consider different tools, methods, and analytical techniques for the condition assessment and diagnosis. A management planning process could then explore mechanisms to minimize or mitigate their effects.

It is clear that the long-term preservation of these unique Djin Blocks is extremely challenging; exposure to the environment, and difficult site management conditions, impose severe constraints on what can be realistically achieved. Proper maintenance of the Djin Blocks is an essential first step in protecting them against the devastating
effects of natural, environmental, and anthropogenic risks. Due to the Ordovician sandstones material of the Djin Blocks, which have a relatively high porosity, risk mitigation and preparedness should be interwoven into everyday management. However, the risk identification and assessment approaches presented in this research enable explicit methods to be developed for systematic management approaches to the maintenance and preservation of the Djin Blocks.

In addition to the design and implementation of emergency first-aid conservation for the Djin Blocks, it is also anticipated that the following actions would be important:

1. **3D digital photo-models, in combination with multispectral imagery (such as visible, near-infrared, and thermal infrared imagery), and terrestrial laser scanning:** this can be used to assess and monitor the state of preservation, as well as to study, visualize, analyse, and disseminate the monuments virtually. The combination of the different multispectral bands and combinations of them can yield comprehensive data to analyse the state of preservation of the monument (Lerma, et al., 2011).

2. **Establish a database of cultural assets in a Geographic Information System (GIS):** to include the survey and cataloguing of all Djin Blocks, to gather information on their structural and material conditions. The classification should include location, type, orientation, structure, and material, in relation to their condition and degree of deterioration, decay, and erosion. It should also include pathological investigation (optical microscopic examination and other laboratory tests, XRF, and consolidants) as required.

3. **Create a Djin Blocks at Risk Register:** using the above to data to categorize scales of risk.

4. **Guidelines for planning and implementing mitigation measures:** covering issues such as the water systems, evacuation plans, and community volunteer training.

5. **Establish margins of safety, in relation to durability, for all possible actions, including natural disasters and adverse environmental conditions, which may alter the Djin Blocks material and structural properties.**

**Design and implementation of emergency first-aid conservation**

It is evident that there is a need to prepare and implement an emergency action plan for first-aid conservation. These actions should be based on the results of the current technical assessment. The plan should mandate the development of a comprehensive inventory of cultural heritage assets, conduct more detailed studies to determine the different kinds of vulnerability, and recommend technical mitigation measures.

For Djin Block No. 9, the following actions are essential. These actions can be used as the baseline to carry out the design of a long-term plan for the protection of the other Djin Blocks:

1. **The top of the monument:**
   - Rainwater is most likely one of the main reasons for the mortar damage at the top of the monument and for the degradation of the mortar jointing the inset stones. The grave on the top collects rainwater over a long period of
time, it elongates the contact time for water action and deeper penetration in to the stone, thus creating more detrimental effects. Preventing prolonged and direct contact with water is a priority. During the winter, the grave should be closed to prevent rainwater storage.

• Water flowing down the façades is causing damage to the stone and affecting the mortar. Appropriate water drainage for the top of the monument, and consolidation, is critical.

2. *The stone inset cornice groove:*

• The removal of the damaged mortar below the stone insets is of highest priority. Mechanical removal is suggested and any remains could be gently cleaned. The stones should be cleaned after removal and consolidated before reattachment.

• New compatible inset stones should be put in place in order to protect the groove in which they are held. This will also enhance Djin Block No. 9 and its interpretation to the public. The inset stones should be carved from Ordovician sandstone, but of low porosity.

• The use of traditional mortars is recommended. However, a special mortar mix, using Silica Sol, can also be used to create an artificial mortar, which could reduce its susceptibility to water flow (Kuhlenthal & Fischer, 2000).

3. *Cracks, holes, and gaps of the Block:*

• Injection mortars should be used to fill cracks and holes, especially the horizontal crack near the bottom of the monument. Meanwhile a sacrificial mortar should be used in places where heavy gaps and alveolar weathering have occurred.

• Consolidation of the friable area of the monument should use Funcosil products, which have been used in The Petra Stone Preservation Project (Kuhlenthal & Fischer, 2000).

4. *The Block base:*

• Drainage at the base is needed to reduce water pools in winter and avoid prolonged contact. The small excavation trench to the north-west of the Block should be closed to prevent rainwater storage.

• Salt removal should be undertaken using a poultice of Kaolinite, clay, cellulose and water (2:1:1:2). A wash with dilute consolidant may be necessary before this is undertaken.

5. *Capacity building:*

• Appropriate training for those responsible for the implementation of these activities should be organized.

**Conclusion**

Long- and short-term deterioration and damage processes at Petra make the use of the latest documentation techniques a basic requirement for any condition assessment, which should in turn act as a platform for risk assessment, and subsequent management and conservation planning.

The results obtained from this study significantly assist in planning the conservation of Djin Block No. 9. It serves as a framework for identifying risks and vulnerability,
assessing impacts, and proposing mitigation strategies. The proposed approaches also provide a guide for assessing, mitigating, and monitoring the risks facing the other Djin Blocks. Indeed, this approach can contribute to the design and implementation of wider management and conservation systems. All of this requires a multi-disciplinary approach, with the cooperation of monument owners, archaeologists, architects, scientists, conservationists, restorers, and users.

Any management and conservation plan for the Djin Blocks should be an active plan, allowing for monitoring and updating information. A strategy based on practical testing, continual monitoring, and preventive care should take place in order to develop an appropriate practice for each type of risk. The weathering conditions on relatively highly porous sandstone monuments require comprehensive control, diagnosis, and analysis. Temperature does not play a major role; water flow and capillary rise are the main mechanisms of weathering, rather than sun exposure. Aeolian weathering is the main mechanism creating damage, as observed on the southern and eastern façades of the Djin Block No. 9. It should be stated, of course, that all factors of weathering operate jointly on the surface and it is not always possible to identify which form is predominant on a particular spot on the façade. Higher priority, however, shall be put for implementation of the suggested emergency first-aid conservation actions, to further evaluate and investigate the risks concerning the physical structure of the Djin Blocks in relation to weathering, water, and salt.

More widely, the integration of multispectral photography, digital photography and thermography can provide accurate information to assess the state of preservation, providing a useful tool for the design of more efficient conservation strategies.

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1. Monument No. 9, as numbered by Brünnow & von Domaszewski (1904).
2. The graves found on top of and inside some of the Blocks appear to be a later reuse.
3. Any management and conservation plan for the Djin Blocks should respect the authentic water systems, to reduce the adverse effects of weathering and ensure the treatment of the heavy salt infestation.

Bibliography


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