CONSERVATION INVENTORY SYSTEMS FOR MONITORING AND PROTECTION OF CEMETERIES AND TOMB FACADES

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Historical and archeological sites, urban centers and parks show plenty of comparable monuments. Many of them, for example tombstones are in bad condition or have tended to be poorly maintained. For further treatment and risk management a system for safeguarding was developed and established for the monitoring of two case studies, namely the rock-cut tomb-facades in Petra (Jordan), and a historical cemetery in Goettingen (Germany).

Historical cemeteries are good for studying various aspects of conservation. We can observe inscriptions on objects constructed over the centuries in a variety of different materials, mostly dateable, more or less comparable in dimensions and exposed to the similar environmental conditions.

Christian cemeteries commonly preserve monuments from the late 18th century onwards (Sörris 2009). Cemeteries of Islamic and Jewish originate from much earlier times. Necropolises are found in mostly all ancient cultures all over the world. Historical cemeteries not only provide interesting documentation of local history and culture, but also offer a serious challenge for heritage conservation. Commonly, there may be no living relatives of the deceased, and consequently preservation of commemorative monuments becomes a responsibility of the general public. Preservation and restoration would cost millions in the case of almost every historical cemetery. It was calculated for the case of the historical Bartholomew cemetery, presented later on as a case study, that a general restoration would cost 2,662,833 million Euros (Bruch 2002).

Because of the sheer number of objects and the limited funds dedicated to preservation, questions have to be asked, regarding priorities and what can be realistically achieved. The main task of a conservation inventory is to assess the degree of deterioration and to offer recommendations for a conservation strategy.

In general, a conservation inventory can embrace many scientific fields and questions. The range of data acquired during systematical investigations can be used for different purposes, for example, in the study of history of art and culture, the usage of materials and the identification of weathering processes.

The study of sepulchres is a small but self-contained field of research within anthropology and history. A unique European study center and museum exists in Kassel, Germany.

Historical cemeteries frequently provide areas of study ground for geologists, geomorphologists and conservators. The focus of their work is the observation, measurement and statistic evaluation of weathering phenomena. Tombstones are special study objects due to the fact

that normally the year in which they started to be exposed is known. They have been used in previous studies to determine weathering rates. In the 1980s, several studies were undertaken to compare the impact on weathering loss of different atmospheric pollution histories (Dragovich 1986, Cooke 1989, Attewell, Taylor 1990).

The weathering of tombstones has been studied for a range of purposes, for example: to document different materials (Inkpen 1997) or topography (Rahn 1969). Chosen materials have been examined in relation to sources of local building stone (Grimm, Schwarz 1985). But in most studies, historical cemeteries have been used to determine the rate of weathering of natural stone (Klein 1984, Grimm 1986).

The inventory system presented in this paper, enables further conclusions to be documented on weathering processes.

The inventory system

The need to document cultural heritage and historic areas worldwide was first highlighted by the United Nations Education, Scientific and Cultural Organization, UNESCO (UNESCO 1976). Following on, the German national commission for heritage conservation provided further recommendations on this topic (Deutsches Nationalkomitee 1982), and the International Commission on Monuments and Sites, ICOMOS, adopted guidelines for the recording of monuments (ICOMOS 1996).

Based on these general guidelines the present authors developed a documentation system which attempts to collate all relevant information of cemetery objects, including the name of the monument or the buried person, together with details on the type of the monument, date of erection, current or historical inventory numbers, artist, sculptor or builder, location and a short inscription (fig. 1).

The date of inspection and the people in charge are documented. All the details concerning the dimensions of architectural building parts, the type of materials, varieties and their manufacture are tabulated. Centred photos of the object are inserted according to the date of erection of the monument. Below these photos is information on all inscriptions, including details on the font, font style, damaged or missing characters and extended words as well as their sources.

MONUMENT CHARACTERISTICS Adolph von Stralendorff

type:	pylon-tomb	**inspection:**	August 2008
category:	monument	**persons in charge:**	Doreen Frydas, Kristina Schindler
time of erection (period):	1811 (classicism)		
inventory no.:	73	**photographer:**	Wanja Wedekind
scultor/workshop:	Christian Ruhl (1764 - 1842)	**data sheet:**	73
location:	Bartholomew cemetery, Goettingen/Germany	**priority:**	47,5
short inscription:	Pylon-tomb with coat of arms and sculture on a slap.		

construction	length (cm)	width (cm)	height (cm)	material / variety / bedding
Überdachung	62	62	35	sandstone / white /parallel to the bedding
Pfeiler mit Figur	55	55	109	sandstone / white-orange / perpendicular to the bedding
Sockel	67	67	23	sandstone / white /parallel to the bedding
Platte	146	140	10	sandstone / red /parallel to the bedding

north	east	west	south
~~Hemme deutscher Jüngling / nicht die Thränen / Deutscher Mädchen / Laß die Harfe tönen / da verdient ihn deutschen Brudersinn / Um ihn tönet / jedes Edlen Klage / Uns es weint / an seinem Sarkophage / seiner Vaterlandes / Genius~ (Inschrift ergänzt nach Sig. Bielefeld)		Thuiskons Liebling / schön in seiner Stärke / Ausgeziert zu edlen / Ritterwerke / wähnt er nur / im Heldentod Gewinn / doch da walteten / die höhern Mächte / Schützen wollt er / seiner Freundes Rechte / Und des Freundes Stahl / streckt ihn dahin.	Adolph von Stralendorff / geb: zu Bergen: d: 10 Juni 1791 / gest: zu Göttingen: d: 24 Aug: 1811.

font: serif style / color: rot / A = character damaged, A = character hypothetical, ? = character lost, A = after descent

eferences:

ld Nr. 11 / Grab Nr. lt. Liste v. 05.02: 73

Schrader, Kahweci, Hermsdorf „Prioritätenliste der Grabmäler": Maßnahmenkatalog 6, Stadt Göttingen, Stadtgrün und Denkmalschutz, aufgestellt: FD 63.4 Denkmalschutz, 15.09.2003, S. 3.

nventar Butkereit 1996, Bd. 2, Nr. 73.

Katalog Döring 1984: 36.

Jürgen Döring, Die Grabmäler des 18. Jahrhunderts in Göttingen. Göttinger Jahrbuch 1884, Göttingen 1984, S. 203-204.

History of the object and restoration:

- Repairs in cement mortar
- paint of the inscription is renewed

Fig 1. Monument characteristics of the tomb Adolph von Strahlendorf at the Bartholomew cemetery in Goettingen (Germany).

Value	Color	Intensity
0 - 10	White	Good condition.
10 - 20	Yellow	Small reparation works.
20 - 30	Orange	Indirect need of restoration.
30 - 40	Red	Immediate need of restoration.
40 - 50	Dark-Red	Strong need of restoration.
50 - 60	Dark-Red	Risk for the monument, strong need of restoration.
60 - 80	Dark-Red	Danger for the monument and the public, strong need of assurance and restoration.

Intensity and definition of the damage index.

Key information for future planning is given by the evaluation of the state of preservation. Therefore, for each direction of the object, various symbols, forms and colours are defined to assist the characterization of different types of conditions, damage, weathering phenomena and their intensity. These symbols are organized in tables, each corresponding to the different object orientation. A square is used when further observation needs to be made; a circle underlines the need for action and a triangle highlights potential risks for the monument and public and the need for immediate attention. Weathering phenomena and descriptions follow the ICOMOS-ISCS illustrated glossary on stone deterioration patterns (Vergès-Belmin 2008). The percentage content is calculated by mapping, using an optical raster-system. Each symbol type is linked to a value and can be highlighted with a graduated colour. This colour distribution shows the intensity of weathering and the percentage area of the monument that is affected. (fig. 1). Based on all values, a final number is calculated which is used to prioritise the object regarding the need for further action. This final value is highlighted with a signal color. In the case of the Bartholomew cemetery these values range from 0 to 80 (Table).

On the bottom of each data sheet, references such as sources and literature are given as well as a short overview about the history of the object and its restoration (fig. 1).

Case study: Petra (Jordan)

The ancient rock city of Petra, which lies south of the Dead Sea in the Hashemite Kingdom of Jordan, displays with its unusual sandstone architecture an abundance of evidence of the Nabatean culture. For this reason, Petra and its almost 4000 individual monuments was inscribed in the World Heritage List of the UNESCO in 1985.

Petra has gained special recognition for its hundreds of rock facades, mostly family tombs, carved out of the sandstone rock found there. The ancient stone city was the capital for the Nabateans from about 400 BCE until the fourth century CE and housed 30,000-40,000 people during its heyday.

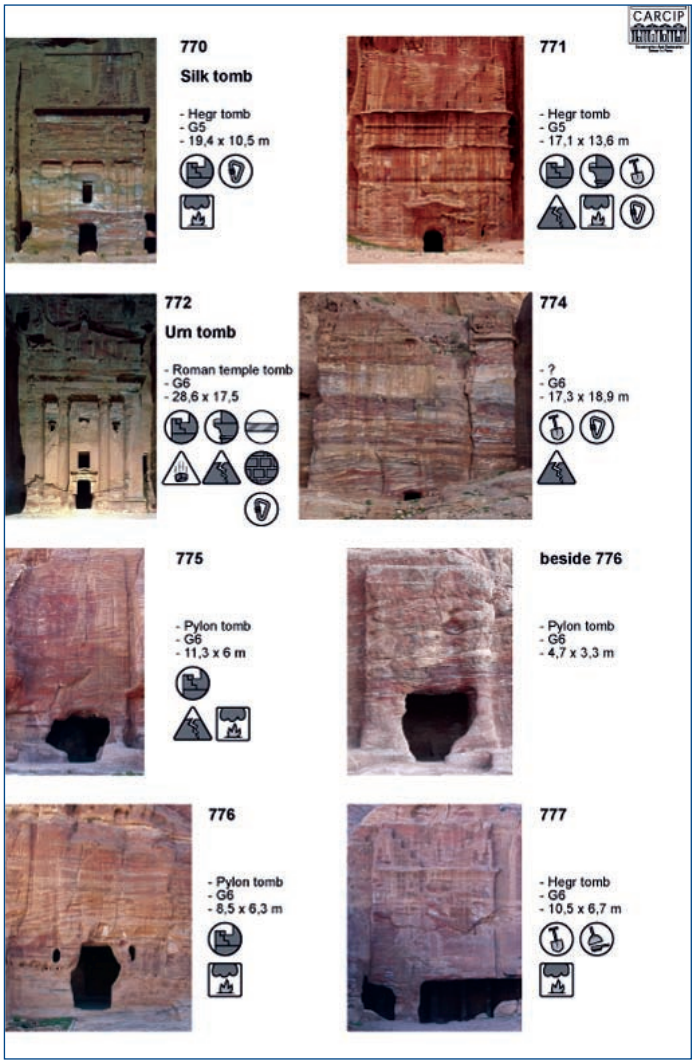

Figure 2. Data sheet with single facades, description of type, dimensions and instructions.

To date, no comprehensive inventory has been compiled for the monuments in Petra. The German building researchers, Brünnow and Domaszewski, published the first survey of the monuments of Petra and proposed a numbering system that is still in use today (Brünnow, Domaszewski 1904). A second survey attempt was made by the former director of the Institute for Antiquity and Christianity of the Holy Land, Gustaf Dalman, who also created a numbering system for the buildings and extended the list to approximately 1000 monuments (Dalman 1912). According to our inspections, of the 831 monuments that Brünnow and Domaszewski surveyed in Petra, 539 were catalogued as stone facades. During the present on-site field research, an inventory was created and representative photographs and written descriptions were made of the condition of 211 monuments, or one third of all the tomb facades (fig. 2).

The inspections showed that over one-half of all the stone facades were equipped with drainage systems. These gutters and canals supplied the cisterns with rainwater and formed part of the water supply. These complex drainage and water supply system composed of open basins, rock carved cisterns of various forms and dimensions, and dams (fig. 3).

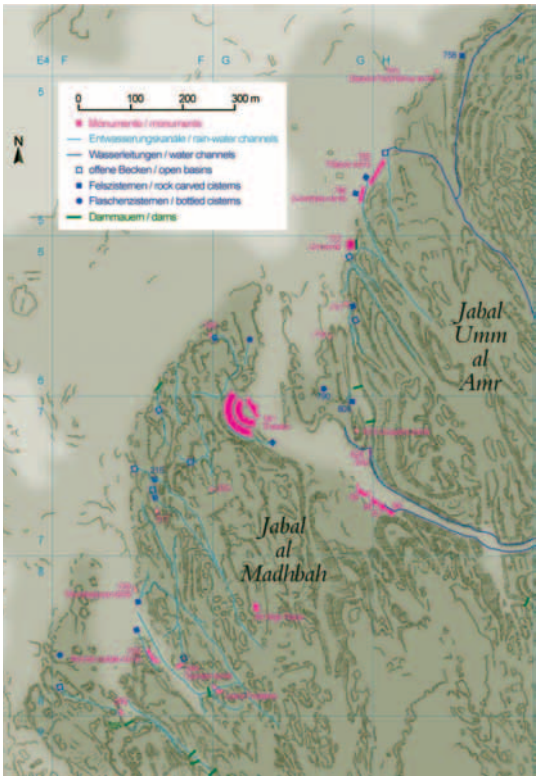

Fig. 3. Area under investigation with the ancient drainage and water supply systems.

In most cases however, the canals are blocked by rubble or are damaged so that the water now drains in an uncontrolled way over the rock facades and damages them. The Corinthian Tomb, the Renaissance Tomb and the Urn Tomb along the Kings Wall in the city center are particularly prominent examples of this phenomenon. To develop the inventory, a form sheet was designed and completed for each monument, which was then inspected according to a catalogue of different criteria (compare fig.. 1, 3). Special attention was paid to drainage systems, static tension cracks, loose ashlar blocks and rock slabs, rubble and dilapidation. Furthermore, stucco decoration and paint remains were searched for. Former and present use of the tomb interiors by the Bedouin Tribe, which inhabited Petra into the 1980s, was recorded. Simple checklists and symbols were used in order to create a quick overview of the condition of each particular monument, to ensure easy and understandable use of the inspection sheets, and to facilitate communication between colleagues. After evaluation of the inspection sheets, it became clear that, at present, many of the stone monuments with drainage canals in the eaves are blocked with rubble or partially destroyed or damaged. The lack of care and maintenance can be seen clearly in the situation in front of the monuments and in the tomb and cult chambers. Over 70 % of the examined buildings are covered in rubble. At the time of inspections, over 30 % were polluted by human or animal excrement or by garbage and rubbish. Over 20 % of the inspected cultural buildings showed remains of mortar, paint or stucco. Almost 30 % of the monuments that were built of ashlar are presently in danger of collapsing. Larger rock fragments are also threatening to collapse. The situation at the Palace Tomb, which presently consists of 8 % ashlar, next to the King's Wall is particularly alarming (fig. 4). Approximately 30 % of all monuments are covered in cracks and crevices, which pose a danger to both the building stability and visitors. Only three tomb vaults, i.e. 1.4 %, in the inspection area are still inhabited by a Bedouin family. In general, the centuries of Bedouin settlement in the monuments did not cause much damage. The Bedouins made very few constructional changes to the monuments, and those that they did are potentially reversible. Also, only a few changes were made in the tomb chambers. However, open fires for cooking and heating have left visible marks in the rock vaults. The dense, black soot on the sandstone sur-

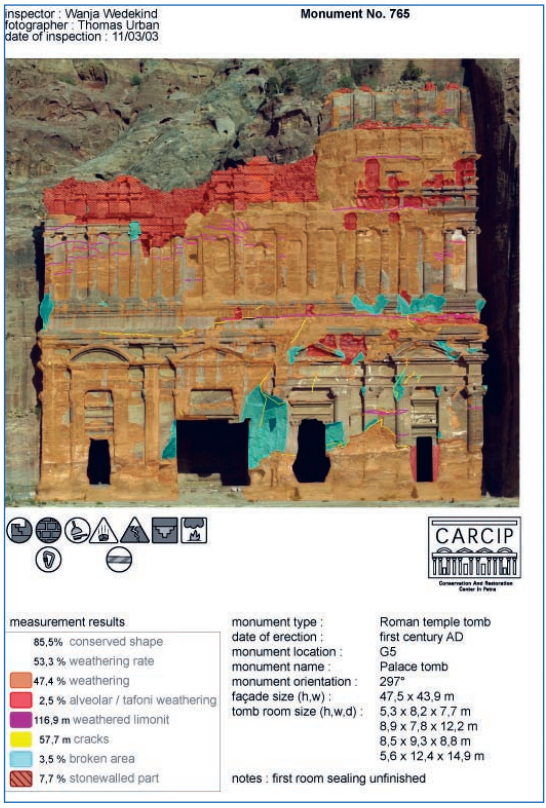

Fig. 4. Prototype of a monument characteristics for the Palace tomb in Petra.

face is very difficult to remove. With regard to signs of settlement, it is apparent that only a little more than 30 % of all examined tombs were used as residential or living quarters. We found these quarters most often in areas supplied by cisterns that were used until recently or until the present day. During the compilation of the inventory, numerous cultural monuments were discovered, mostly cisterns, that had not been mentioned in the reports made by Brünnow and Domaszewski. A series of rock facades were also examined for which there were no numbers or names. Our field research on-site made it clear, however, that only clean-up work or small repairs were necessary in most cases to make the drainage systems functional again.

Maps of the weathering rate and the weathering intensity were made based on photographs rectified to the architectural dimensions of 14 other monuments along the King's Wall (fig. 5).

The aim was to evaluate which weathering forms predominate and to assess the condition of the tomb facades. Back-weathering of varying intensity and form is found on the monuments. The solid rock of Petra's Cambrian sandstone is characterized by two typical weathering forms: alveolar weathering, also described as alveoliation and tafoni weathering. Holes, hollows and erosion varying from a few centimetres (alveoles) to several meters (tafoni) are characteristic of this form of weathering (Kirchner 1995), which in Petra can be attributed to the salts. Another form of weathering can be defined as back-weathering parallel to the surface due to the process of sanding and flaking.

Due to the annual heavy rainfall in February and March, sudden floods regularly occur through the narrow Wadis. As mentioned above, these floods are the biggest danger to the monuments.

The erosive impact of the water, however, plays a subordinate role. Instead, the water serves as a transporting medium for the damaging salts which concentrate on the rock surfaces. The water diffuses through the mostly coarse, porous sandstone dissolving some of the salt out of the rock structure. This salt recrystallises on the surface of the rock and leads to damaging efflorescence. The destructive salt is Halite (NaCl), or rock salt, as demonstrated by numerous authors and ourselves. Aside from this surface weathering, the so-called alveolar and tafoni weathering defines the stone relief of Petra. Investigations showed two forms of weathering, the surface, relief-like weathering and the

Fig. 5. The tombs of the Kings`s Wall in Petra.

spatially limited back-weathering (tafoni weathering).

The differentiation between the two forms is difficult in places, because there is a transition from one type to the other.

The results of the damage mapping show that data among the defined categories differed greatly from monument to monument. The most similar data was gathered for the obtainment of building outlines, varying between 85,5 % and 99,1 %. This correlates with the perception of the large buildings from afar. Of the 14 mapped monuments, 95,9 % of the buildings still retain their original form and are unmodified by later generations. The area of weathering differs greatly between 18.1 % and 99,9 % with an average of 50,9 % in relation to the surfaces of the facades. Back-weathering parallel to the surface predominates and averages 47,9 %, the alveolar and tafoni weathering shows an average of 11,7 %.

Case study: Bartholomew cemetery in Goettingen (Germany)

The historical Bartholomew cemetery is closely connected to the rise of the Georg-August- University of Goettingen, which was one of the most important centres of science in Europe during the 19th century and in the first half of the 20th century. The cemetery is the last resting place for many distinguished German and European people involved in the humanities and scientific research.

During the 19th century, thirty professors who taught and became renown at the University of Goettingen found their last resting place at the Bartholomew Cemetery. The number of tombs preserved today comprises a total of 167. Many of the tombs only show fragmentary preservation. The types of graves found at the cemetery consist of simple enclosure graves (6 %), tomb slabs (7 %), steles (17 %), gravestones (14 %), stone pillars (4 %), gothic pinnacle-pillars (3 %), obelisks (5 %), cubic-shaped columns, (1 %), crosses (43 %). There are also two mausoleums.

In the case of the historical Bartholomew cemetery in Goettingen, the model for an inventory system used in Petra was further developed. A catalogue of different damage forms and criteria was created. Special attention was paid to object-specific problems like the foundations, tree roots, and the danger of damage due to branches falling from the surrounding trees. New symbols were designed for all these criteria.

The results of the inspection may be summarised as follows: Regarding types of stone, mostly different sandstone varieties were used (96 %). The oldest tombstones conserved from the 18th century were made from local sandstone (3 %), while around 1 % of them were made from a sandstone variety originating from the workshop of the sculptor, who was based in another town. From the 1880s, a new light coloured sandstone variety was increasingly used. From 1860 onwards marble plates in combination with sandstone were used.

Regarding the observed damages, the inspection has shown back-weathering caused by sanding on the east-facing surfaces of 87 % of all monuments

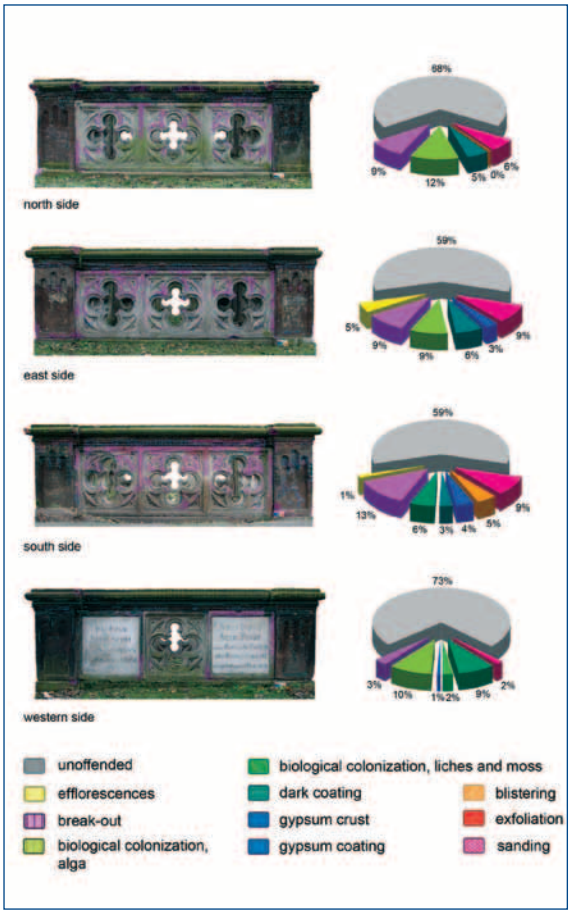

Fig. 6. Conditional mapping of the tomb of Lejeune-Dirichlet at the Bartholomew cemetery in Goettingen.

(Kracke et al. 2007). The same phenomenon was observed on 41 % of the south- and 35 % of the north-facing sides followed by 18 % of the west-facing sides of the monuments. An explanation of the deterioration related to the orientation can be given by the prevailing direction of the wind, mostly coming from the west and north.

Methods for conservation and materials for the restoration of the tombstones were defined and used during a research project in 2006/2007 (Ruedrich et al. 2008). During this project, a condition map of each treated monument was created. The results of the quantitative evaluations of the mappings show correlations with the results of the inventory. The tomb of Lejeune-Dirichlet (1859) shows the highest intensity of weathering on the south side of the monument with a damage rate of 44 % in relation to the surface. The east side follows with 41 %, then the north side with 34 % and lastly the western side with 27 % (fig.. 5). Biological colonization affected the northern and western sides (each 12 %) Mechanical deterioration, including blistering, exfoliation and sanding, affected the eastern (18 %) and southern (27 %) sides.

The conservation inventory shows that only 23 (14 %) tomb monuments strongly required restoration. A further 23 (14 %) needed restoration immediately. With 72 %, the predominant contingent of all tomb monuments is still in an acceptable condition; however, for 19 % of those, a beginning restoration in the near future would be desirable.

Since 2008, stepwise restoration works has taken place according to the priority list

developed from the results of the conservation inventory. The first progress of the preservation works were made by maintenance and restoration, which can be seen in the statistical evaluation (fig. 7). While the condition of monuments in danger could be decreased (50-80), the percentage of monuments in a relatively harmless condition is rising (fig. 7).

Conclusion

More than 200 rock-cut sandstone facades in Petra were examined and mapped using the currently presented inventory system. It was shown that the

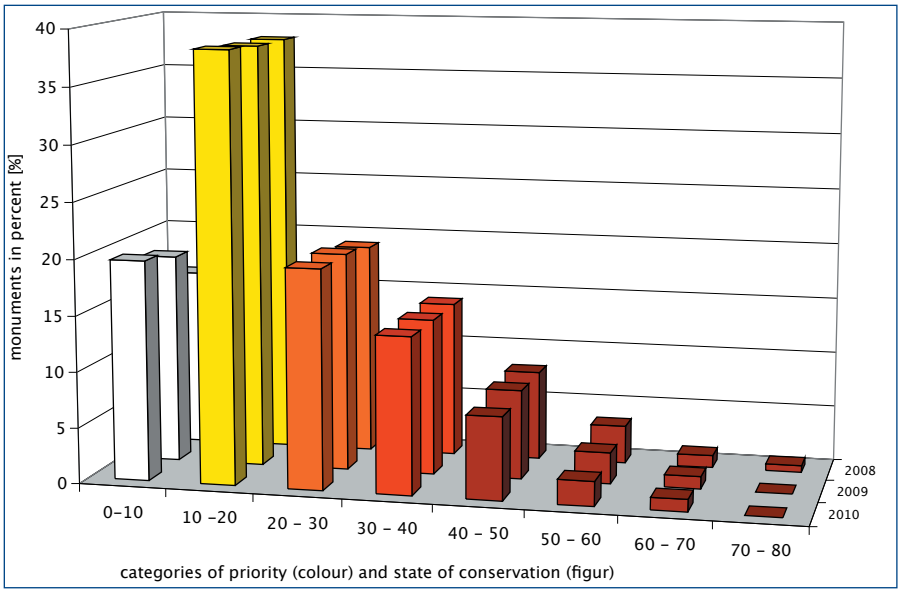

Fig. 7. Development of the state of conservation from 2008 to 2010.

King's Wall and most of the other large tomb ensembles were protected by an effective drainage system, which was an integral part of an ingenious irrigation system which enabled Petra to become a blooming oasis for tens of thousands of people. During the on-site fieldwork, extreme weathering of all the monuments was observed, primarily caused by the uncontrolled drainage of rainwater due to the ancient protective system becoming non-functional. We concluded that the reactivation of certain parts of this system would be an important step towards the preventative conservation of the sandstone facades in Petra.

Consequently, cleaning works and the reactivation of single drainage systems have been undertaken over the last several years.

The inspection of the tomb-monuments on the historical Bartholomew cemetery in Goettingen has highlighted back-weathering phenomena with different intensities, depending on the geographic location of the monuments. The conservation inventory has shown that preservation of the site is possible with manageable costs. Thanks to the conservation inventory a priority list for conservation can be generated for planning further action. With the implementation of an annual budget by the city authorities a step-by-step conservation programme is now assured.

The system presented in this paper is a workable planning and inspection tool for managing Monuments. It aims to inform a programme of conservation that is economically justifiable. Furthermore, the system is applicable for several criteria concerning the site and is helpful for fund-raising. It offers the capability to generate priority-lists and to define action for sustainable conservation. It is recommended that in future, a conservation inventory should form the basis for master-planning of historical sites. ■

Acknowledgements

For their cooperative collaboration on-site, we would like to thank the director of the "Petra Stone Preservation-Project", Dr. Helge Fischer and his team, as well as the director of the Petra Archeological Park Mr Suleiman Farajat and the Department of Antiquities of Jordan (DOA).

We would like to thank the University of Goettingen construction office, the State Office for Preservation of Historical Monuments (Lower Saxony) and the Department for Green Spaces and Environment Göttingen. Our work was kindly supported by the Deutsche Bundesstiftung Umwelt and the Hans-Boeckler-Fundation.

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Résumé

Systèmes d'inventaire pour le suivi et la protection des cimetières et des tombes-façades

Sites historiques et archéologiques, les centres urbains et les parcs montrent beaucoup de monuments comparables. Beaucoup d'entre eux, les pierres tombales par exemple, sont en mauvais état ou ont eu tendance à être mal entretenues. Pour les traitements et la gestion des risques futurs, un système de sauvegarde a été élaboré et mis en place pour le suivi de deux études de cas. Il s'agit des tombes-façades taillées dans la roche à Pétra / Jordanie, et d'un cimetière historique à Göttingen en Allemagne. Le système présenté dans cet article est une planification réaliste et un outil de contrôle pour la gestion des monuments. Il vise à mettre en place un programme de conservation économiquement justifiable. En outre, le système est applicable à plusieurs critères relatifs au site et est utile pour la collecte de fonds. Il offre la possibilité de générer des listes de priorités et de définir les actions nécessaires pour une conservation durable. Il est recommandé qu'à l'avenir, un inventaire constitue un préalable à la planification de la conservation des sites historiques.