UNESCO Documentation & Advisory Services Workshop 04
Beirut — Baalbek
March 26th-29th 2018

Report

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Consultants

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Summary

March 26th-29th 2018, the UNESCO Documentation & Advisory Services (UDAS) Workshop 04 was organised in Beirut & Baalbek. The event took place in the framework of the Baalbek & Tyre Archaeological Project (BTAP), part of the Cultural Heritage & Urban Development (CHUD).

This edition was specifically organised to discuss the conservation works on the colonnade of the temple of Jupiter in Baalbek planned in the framework of BTAP II (section 2). In the present report, comments and recommendations are made on the on-going and future works of stone conservation (section 2.1) and on the proposed structural interventions (section 2.2). They are based on the analysis of the documents sent by CDR through UNESCO – for the present and previous workshops –, on observations made during the two days of visit of the site and on discussions engaged during the workshop in Beirut and Baalbek.

Comments are also made on the structural and surface conservation measures completed in the framework of BTAP I (section 3) and on the presentation measured planned in the framework of BTAP II (section 4).

For the main points raised in the report, refer to the final notes (section 5, p. 33).
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Agenda of the Workshop

March 26th: UNESCO Regional Office, Beirut

– Opening Ceremony J. Kreidi (UNESCO), J. Yasmine (CDR)
– Presentations of the BTAP II Conservation Works at Baalbek World Heritage Site.

Participants:

UNESCO: J. Kreidi (programme officer for culture), M. Hmeidan (technical coordinator), D. Mokdad (administrative assistant),

AICS: G. Chrabieh (officer), M. Calia (architect),

Baalbek Municipality: H. Lakkis (mayor),

CDR: J. Yasmine (project manager), L. Shehadeh (project officer),

DGA: S. El-Khoury (director), L. Salloum (Baalbek site manager), D. Sassine (civil engineer), O. Kallab (architect),


External experts: J. Abdulmassih (Lebanese University), Y. Maacaroun (Lebanese University), M. Hoshaymeh (Private Consultant), M. Chalhoub (structural engineer),

ICOMOS experts: T. Patrício (surface conservation), P. Smars (structural conservation), S. Kelley (structural conservation)

March 27th: Site Inspection Visit – Baalbek World Heritage Site

Participants:

UNESCO: J. Kreidi, M. Hmeidan, D. Mokdad,

AICS: M. Calia,

Baalbek Municipality: H. Lakkis,

CDR: J. Yasmine, L. Shehadeh,

DGA: L. Salloum, K. Rifai, D. Sassine, O. Kallab,

BTAP II: M. Martuscelli, S. De Vito, R. Bozzi, R.-L. Bianchini, G. Sammartini, A. Cali, Z. Nemer, V. Braidy,

External experts: J. Abdulmassih, M. Hoshaymeh,

ICOMOS experts: T. Patrício, P. Smars, S. Kelley

March 28th: Site Inspection Visit – Baalbek World Heritage Site

Participants:

UNESCO: J. Kreidi, M. Hmeidan,

AICS: M. Calia,

CDR: J. Yasmine, L. Shehadeh,

DGA: L. Salloum, K. Rifai,

BTAP II: M. Martuscelli, R. Bozzi, R.-L. Bianchini, G. Sammartini, Z. Nemer, V. Braidy,

External expert: M. Hoshaymeh,

ICOMOS experts: T. Patrício, P. Smars, S. Kelley

March 29th: UNESCO Regional Office, Beirut

– Feedback on surface and structural conservation measures. T. Patrício, P. Smars, S. Kelley
– Closing Discussions and Debate.

Participants:

UNESCO: J. Kreidi, M. Hmeidan, D. Mokdad,

AICS: G. Chrabieh, M. Calia,

CDR: J. Yasmine, L. Shehadeh,

DGA: S. El-Khoury, L. Salloum, K. Rifai, D. Sassine, O. Kallab,

BTAP II: M. Martuscelli, R. Hadad, R. Bozzi, R.-L. Bianchini, G. Sammartini, V. Braidy,

External experts: Y. Maacaroun, M. Hoshaymeh,

ICOMOS experts: T. Patrício, P. Smars, S. Kelley

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1 Agenzia Italiana per la Cooperazione allo Sviluppo (Italian Agency for Development Cooperation)
2 Council for Development and Reconstruction
3 Directorate General of Antiquities
Section 1

Introduction

The fourth edition of the UNESCO Documentation & Advisory Services Workshop (UDAS-04) had the specific purpose of discussing the case of the colonnade of the temple of Jupiter in Baalbek.

In relation to the conservation of surfaces, T. Patricio already gave a first feedback at the occasion of UDAS-03 Workshop in 2017 [1]. The present report is another step in the process, in the light of what happens in the interval and of the most recent information (section 2).

In relation to the conservation of the structure, P. Smars did not comment on the specific case of the colonnade in the first two UDAS meetings to which he participated. Nevertheless, comments and recommendations made in the first two reports [2, 3], especially about the temple of Bacchus and more general issues related to modelling, uncertainty, integrity and authenticity are very relevant indeed to the problems faced by the colonnade. Some points are very specific to the works on the temple of Jupiter and to BTAP II, critical to the safety and recommendation are made. Another point is not directly addressed by the work of BTAP II: the seismic vulnerability of the structure, to name the beast. Its was nevertheless hovering on the workshop and shadowing the final discussion. We therefore consider important to face it and give a few advises for the future (and the present) (section 2).

A particular issue for both stone and structural conservation is that difficult choices have to be made. What possibly hinders even more decision is that the factors are not only technical. This is a point that we stressed since we were first involved in the case of the archaeological site of Baalbek. One needs to precisely know what the intervention is supposed to achieve. How to deal with the lichens, or how to deal with seismic vulnerability are typical examples. Another complication is that all the elements (clarity on objectives, but also knowledge, means . . .) are not yet there for a sound approach on some of the problems, specifically the vulnerability of the colonnade in case of earthquake occurrence.

In continuation with previous reports, we also continue to stress as a litany the importance of documentation, monitoring, maintenance, long-term view, management plan . . .

Comments are also made on the structural and surface conservation measures completed in the framework of BTAP I (section 3) and on the presentation measured planned in the framework of BTAP II (section 4). They have to be understood as complement of what was stated in the first three UDAS reports and, when work are completed, as advises for future interventions.

List of documents received from CDR through UNESCO in relation to BTAP II and the colonnade of the temple of Jupiter and in relation to BTAP I before the UDAS-04 Workshop:

- a document prepared by the consultant to describe the proposed structural actions [4],
- the mission statement prepared by the contractors [5],
- a structural report commissioned to the University of Palermo by the contractors [6] with a set of annexes prepared by the University of Palermo and other entities:
  - Annex 1: magnetometric investigations [7],
  - Annex 3: compression and carbonation tests [8],
  - Annex 4: cores and endoscopies location [9],
  - Annex 6: freeze-thaw [10],
  - Annex 7: petrographic analysis of stone samples [11],
  - Annex 8: analysis of deposits [12],
  - Annex 9: additional corings [13],
  - Annex 10: cleaning tests and samples [14],
- the progress report published by UNESCO [15],
- File received from the contractors at the end of the mission, March 29th 2018: “Annex 12: products datasheets”.

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Section 2

Archaeological site of Baalbek - Colonnade of the temple of Jupiter - BTAP II

2.1 Stone conservation

The situation is complex and delicate. The temple of Jupiter colonnade is a heritage of major importance, a symbol for Lebanon! The task is huge and entails great responsibility.

The colonnade is composed of richly decorated elements, with a very refined stone carving and a very specific architectural expression. Unfortunately, it is precisely these elements which are mostly effected by advanced and complex decay and weathering: micro fissures, cracks, detaching elements, important lacunae, heavy biological attack (lichens), etc, etc.

To make the matter worse, the degradation of the stones of Jupiter’s colonnade is not only affecting the “surface”. A simple “cosmetic” scrubbing is not the solution. The stone blocks are attacked on the surface (by pollution, lichens, humidity, etc.) but also attacked in their mass. In the 1930s, large quantities of iron and cement were inserted and corrosion threatens the material.

In its beginning stone conservation in an archaeological context consisted in restoring an ‘old’ or ‘ideal’ state of the remains, every so often at the cost of strong interventions: major repairs, replacements of stone, filling gaps, anchoring… Although, in their time many these interventions were made with care and professionalism, the use of certain materials (cement mortars, irons…) proved in particular to be harmful (sometimes even ineffective) because of their incompatibility with the original structures. And the irreversibility of the interventions is especially problematic.

Baalbek bears witness of this historical phase with the colonnade of Jupiter as one key piece of evidence.

Nowadays, the current doctrine is characterised by much more cautious objectives and principles. Minimum intervention is promoted. The original materials must be modified as little as possible. The interventions should only improve the conditions of conservation of the artefacts, their state and environment, in order to extend their life.

Today’s approach proceeds according to the following steps:

- Diagnose, prior to the works - Investigation and mapping,
- Remove the causes of the alterations - if possible by acting upstream on the environment,
- Restore the remains (repair, clean, and consolidate)
- Protect the restored remains – against future damage by ensuring its maintenance.
- Prevent damage, a new approach has gradually been added - preventive conservation.

In the definition of Baalbek Outstanding Universal Value, criterion (i) is used: “The archaeological site of Baalbek represents a religious complex of outstanding artistic value and its majestic monumental ensemble, with its exquisitely detailed stonework, is a unique artistic creation (…)”. The conservation of the exquisitely detailed stonework is therefore of paramount importance.

The documents received by the contractor present adequate measures and methodologies. The “Method Statement” is well presented. However, it is regrettable that we received the documents with
Figure 2.2: Degradation types on the entablature of Jupiter Temple: fissures, cracks, detaching elements, lacunae, biological attack... Patrício, 2018
the technical datasheet of the various products only during the last day of the mission. The principles and criteria defined for the conservation measures of the stone are adequate and we appreciate the concerns about proposing cleaning only for incoherent deposits.

We are very pleased that the mapping of the decay was updated as recommended last year [1]. The necessary complete updating will only be possible after cleaning of the surfaces. As stated in the “Method Statement” the large amount of deposits does not allow a definite inspection of the surfaces. The complete set of the decay patterns’ mapping is a very important document that should be updated as the works progress and should become part of a Damage Atlas for Baalbek archaeological site (Teresa Patrício, “Condition survey and damage atlas of Baalbek” in [17]). Moreover, the Baalbek Damage Atlas could be completed with the data from all the trials made by the consultants of BTAP I and BTAP II. As advised in our report of 2017 [1, p.26], it would be interesting to have a detailed report on mockups, their results, choice process and interventions; a kind of inventory of trials and procedures specifying exactly which materials were used, in which proportions, solutions, following which application methods and describing the outcome (being positive or negative). The information on non-advisable materials and methods, and their justification, is also of great importance and usefulness for the planning of future works.

The degradation patterns are so specific that some of the solutions for the surface consolidation are very closely connected to the structural reinforcements. It is necessary to grasp the problems globally, to look and treat the block of stone in its totality, in its mass. With the proposed methodology and techniques it is clear that it is not a “cosmetic” matter!

Considering the value of the colonnade and its decorative elements, it is imperative to properly formulate the reasons behind the choices made for this project in order to give the right answers, and this should be done by all of us:

- What is the expected result?
- What is the visual aesthetical look that we want to achieve?
- For how long do we want to preserve it?

These are a few questions that are important for the definition of restoration criteria and for the final decisions.

The visit of the site gave us a close and direct confirmation of how the colonnade is an extraordinary example of Roman architecture with remarkably interesting details. A detailed architectural study and mapping all of the existing original painting should definitely be considered. Moreover, we were also very pleased that historical iconography from the DGA was made available to the consultant (as suggested in our report [1]).

During the visit of the site, we could also discuss products compositions and check that a complete assessment, with an extensive mapping of the various degradation patterns had been prepared for all the capitals and the complete entablature. Is very clear that gathering knowledge on the monument and its stone surfaces has been a major phase, fundamental for the assessment of the existing decay, and that it was only possible after the placement of the scaffolding.

The causes of degradation are multiple. A diagnosis has been established, and even if for some aspects improvements are needed, the main causes of deterioration are identified and the state of conservation of the stone recognised. Not necessary in the following order, it is required to:

- Stop and stabilise the alterations by eliminating
when possible the agents responsible,

- Apply suitable treatments,
- Repair (completion, filling gaps, ...) the degraded areas,
- Protect the treated areas,
- Know, predict and monitor the effects and impacts of the conservation / restoration intervention on the original features.

### 2.1.1 Cleaning

Cleaning is one of the major challenges faced by the conservation project.

Various elements are found on the surfaces: mineral particles (grains of sand, clay, salts ...), organo-mineral products resulting from urban activity (fly ashes, soot, oils and combustion residues), plant and animal matter (pollens, algae, insects and bacteria). All of them form surface deposits (crusts) which according to exposure and orientation are loose or firmly encrusted, thin or thick, orange, greyish or black.

The epidermis of the stones has undergone transformations that weakens it (patina and epigenic layers). The cleaning technique has to be carefully, case by case, adapted to the type of dirt.

If, in some areas, cleaning with water and brushes (Figs 2.5, 2.6) is suitable (as seen during the visit), it is not the case everywhere. The biological infestation is widespread, large areas are affected with very firmly encrusted lichens, many areas are covered with very thick and hard black crust (in the capitals, architraves extrados, friezes ...).

It is important to keep in mind the concrete implications of cleaning this type of incrustations.

We were very pleased with the discussion about patina. The Method Statement states that:

> "whatever the cleaning treatment will be applied, it will never remove the patina, wherever it is still preserved. As everywhere, only the deposits will be removed" [5].

But, the cleaning of encrustations implies actions continued until the crusts are completely removed which, in many cases, will mean removal of the patina and, more importantly, removal of the natural stone surface.

This type of cleaning, will for the least strongly affect the colours and will require chromatic revisions and corrections (section 2.1.7) and protective treatments of the areas treated (section 2.1.8).

To appreciate the proposed cleaning methods, commonly used criteria in the world of stone conservation may be verified. The proposed methods must:

1. be effective,
2. not cause direct or indirect damage to the stone surfaces,
3. allow the best possible preservation of the epidermis, the patina of the stone,
4. not generate harmful products or accelerate the ongoing alteration processes,
5. be controllable: the operator must be able to adjust or stop cleaning at any time [18, 19] (this aspect is of utmost importance).

During and after the works of cleaning, a scientific control of the cleaning by an independent laboratory is advised specially for qualities of the methods, seriousness of the monitoring, quality of the results, (determination of residual material, salts ...).

### Lichens

Lichens are very widespread, they cover about one third of the surface, especially on the southern side of the columns and on the entablature. Their complete
elimination would bleach and lighten the surface of the treated areas (bare and decorated).

Benzalkonium chloride has been tested. This product has a high germicide power. After the three applications tested by the contractor, the lichens appear to be killed but still firmly encrusted within the stone. If it is decided to remove them completely, a mechanical action will have to be applied (using for instance scalpels or, because of the large surface to be treated, micro-sandblasting).

We advise rethinking about the whole procedure and its consequences, and decide whether lichens should be removed or not.

To completely remove them will unavoidably damage the surface. In the highly decorated elements (often strongly affected by lichen attacks), there is the risk of losing part of the surface and consequently flatten the relief of the decorations.

Following the discussion we had in-situ and, for the areas where the lichens are more developed, with deep hyphae, we recommend laboratory analysis to verify the effectiveness of the biocide and the possible requirement for more applications. If the hyphae are killed, we favour monitoring their colours and not removing them mechanically.

**Nebulisation**

For the black crust, the application of chemical patches (chemical cleaning by mean of soaking, as ammonium carbonate) should be avoided as much as possible. The weather conditions are not the most suitable for these patches and depth of cleaning is difficult to control. Moreover this type of foams and poultices compels the use of large amount of water with the associated problems. They should only be used when strictly necessary and for very punctual interventions (small areas).

For the removal of important surfaces of black crusts, water nebulisation (fog) and projection of water under low pressure is proposed. The main problem of this methods is related to the imbibition of the stone resulting from the large volume of water required and its possible harmful consequences such as brown spots due to dirty water drying on the surface of stones and joints, possible salt efflorescence, loss of small stone scales as a result of the dissolution of salts and infiltration of water through joints, cracks, metal pins, alveoli and other cavities.

A constant monitoring is recommended during the cleaning procedure. In order to limit the area to be cleaned, flexible pipes are preferable. The nozzles can be oriented towards the dirtiest areas, and using a soft brush as quickly as possible to prevent the continuous runoff of water along the columns to the base of the colonnade.

In line with what is said above, chemical treatments should be avoided for the finishing phase. When a mechanical cleaning will be necessary, micro-sandblasting should be considered. Chromatic revision will be necessary.

**Micro-sandblasting**

This method is particularly suitable for removing surface deposits but attention should be given to over abrasion and eventual loss of fragile parts. The main benefits of micro-sandblasting are: the possibility to
use it very locally and the absence of risk of water imbibition, infiltration and consequent efflorescence and stains. Nevertheless, there is the risk of grinding surfaces and a significant risk of damage if the manipulator is not experienced and attentive. Do not go too fast and stop as soon as damage appears. Dust can remain on the stone surface, resulting in white tints, possible residual pollutants. We advise to end the cleaning with an air jet. Moreover, we advise to avoid this cleaning method on fragile carved decoration.

This method is very inefficient on plant organisms like lichens. It is only advised for the very dark and hard crusts.

2.1.2 Consolidation

Consolidation is only necessary when stone present serious phenomena of deterioration and alteration. It is therefore a treatment to apply locally, only on degraded areas, to improve the cohesion of the stone in reinforcing the adhesion of the constituents to each other.

A pre-consolidation was necessary because of the advanced degree of degradation and was already extensively applied. In general, the method statement proposes the use of organic resins and organic silicates. The materials are adequate.

Ethyl-silicates when hardened, only keeps 30% of its initial volume, not altering the transfer properties of the material (capillarity, drying . . . ) while improving its cohesion. It is important to pay attention and control penetration. A good penetration of the product is preponderant for the effectiveness of treatment.

The results of the application of the MICROACRIL CV40—an acrylic microemulsion (in a 2-4% deionised watery solution)—looks like very stable and has a good penetration. The cohesion of the stone is visibly improved. A continuous control of the consolidation is advised during the works.

The consolidation treatment must annihilate the effects of the degradation, restore its cohesion to the material, but it does not eliminate the causes of degradation and does not protect the stone against a resumption of the alteration.

Liquid epoxy resin without solvents is used to reattach scales completely or almost completely detached from the stone and to neutralise cracks. The product has a high adhesive characteristic and excellent mechanic properties. Leakage of the resin should be avoided. In order not to create watertight barriers and strong point, planes should never be lined with glue, but proceeding by small sticking points. The rest of the voids should then be filled with a fine mortar or a grout injected by means of a needle.

When the parts to be glued are large and heavy,
pins should be used, in glass- or carbon-fibre. It is better to place several small pins regularly distributed than a large central anchor.

2.1.3 Cement joints Removal

The method statement proposes to remove the small reintegretion of the 30s (cracks and lost material), executed with cement, mechanically and– where required– with air compressed micro-chisel. We recommend special attention. The air compressed micro-chisel is to be used locally and only for small reintegrations and stop before reaching the epidermis of the stone, finishing the work with a milder method.

2.1.4 Pointing and micro-pointing

Natural Hydraulic Lime based mortar are commonly used in restoration due to their compatibility and to their resilience to harsh conditions and normal weathering. Nevertheless, durability of the measures, harsh weather conditions, and difficulty of access should be addressed. Support compatibility issues are common and limit the durability of the repair. To ensure good compatibility between the original stone and the repair mortar, care must be taken to minimise material differences on capillarity, elasticity (rigidity) and mechanical strengths (flexion, compression), permeability to water and resistance to thermal expansion. Attention should be given also to colour and surface appearance.

In general we advise mortars that are less resistant, more flexible, more capillary and more permeable than the original stone, in order to favour the (future) deterioration of the repair material.

2.1.5 Completion and filling gaps

Gaps should only be filled in specific circumstances: for structural reasons, to avoid water penetration or water damp.

As discussed on site, liquid epoxy should be avoided as much as possible for big voids. When necessary, it should only be used to create punctual bridges, filling the remaining gaps with an epoxy-based mortar. Unfortunately, the proportions were not specified but we advise using crushed lime stone as a filler, similar to the one used on the colonnade.

2.1.6 Metallic elements

Information about the pins is incomplete (diameter, and length). Improving knowledge is certainly not easy but rust is visible on the outer surface of the pin section, stones are often very fractured, and in some cases cracks induced by crushing and by oxidation of the iron pins can be observed (Fig.2.23). Corrosion is certainly a concern. A passivation product was applied but only treat a very small part of the pin. Recommendation are made in section 2.2.3

2.1.7 Chromatic revision

Concerning the chromatic revision and corrections, we recommend great moderation, trying only to attenuate very strong changes of colours and hard transitions.

2.1.8 Final protection

Protection is the final phase of the restoration and is very important after cleanings actions. The effectiveness and durability of the protection and water repellent depend on the stone, the products and the quality of application. Quantities and climatic conditions are in particular important.

Moreover, it is important to remember that such treatments decrease the drying rate and the water permeability of the stones. It should therefore be avoided on surfaces behind which water can arrive (bases subjected to capillary rise, voids, cracks, defective joints…). After treatment, water evaporation will be difficult and its retention favours degradation, especially of the iron elements inside the stones. The role of the support is essential in the efficiency and the durability of the treatment: before hydrofuging, we advise therefore to carry out tests on the different types of materials of the colonnade.
2.2 Structural Conservation

The structural vulnerabilities of the six remaining columns of the temple of Jupiter (Fig. 2.1) are present at various levels, some of them endangering the global stability of the structure (potentially leading to major or total collapse), others endangering local areas of the structure (from small fragments to bigger blocks). At each of these levels, the risk is high. This is shown by the studies [20, 21]. Our discussions during the workshop with the engineer (thanks to him for being present at the workshop), the contractors, our colleagues and our personal observations on the site reinforced our confidence in this diagnostic. This is actually in line with what is discussed in the introduction of section 2.1. There is a continuity running from the micro- to the macro-level requiring a global approach, specifically between cleaning (section 2.1.1) and problems of local stability (sections 2.1.2, 2.1.5... 2.2.2).

At each levels, risks have to be defined, possibly measured and decisions have to be taken to deal with them, looking at the costs and benefits that interventions or non-intervention may have on the structure and its values.

In our understanding, the heavi ness of the interventions necessary to mitigate the risks correlate with the size of what needs to be secured. It is a first element to consider.

Heavier interventions are obviously more costly, not only in monetary terms but also in terms of the preservation of the authenticity of the fabric (and other values) as discussed in detail in our report of the first UDAS workshop [2] and other documents [22, 23, 24, 25, 26].

Heavier interventions, especially if the context is uncertain, also require more studies and preparation [27].

Ensuring the stability of smaller fragments is easier and arguably less controversial in terms of authenticity.

Anyway, a line has to be drawn between the risk which are going to be mitigated by an intervention and the risk which are going to be accepted. This line always exist: there is no such thing as zero risk. Anyway, a line has to be drawn between the risk which are going to be mitigated by an intervention and the risk which are going to be accepted. This line always exist: there is no such thing as zero risk. Ensuring the stability of smaller fragments is easier and arguably less controversial in terms of authenticity.

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Figure 2.11: Columns of the Jupiter Temple before the installation of the scaffolding. Smars, 2015
ity and coherence of the entablature which now act more like a single block. Is it something positive? The question is complex and was not studied. We may conjecture both positive and negative effects of the intervention. An event similar to what happened in 1759, seeing some of the columns (three) falling down and others (six) remaining standing is anyway now unlikely. Either all the structure will resist, either all the structure will collapse.

Given these premises we have little doubt that the risk of collapse in case of a significant earthquake is high. The mathematical models point also in that direction, the margins are small.

For smaller earthquake, the estimates are more optimistic.

But it seems that the studies did not convey a clear message about the risk. In the consultant "explanatory report" (not dated: 2011? 2012?), it can be read:

"The results of the study revealed that the colonnade would reasonably be able to bear the expected seismic action if previous interventions were consolidated." [31, p. 29]

And the "technical and calculation report" (not dated) concludes:

"The results of different analysis agree in highlighting a good capacity to the earthquake." [32, p. 40]

The DGA showed signs of discomfort and discontent during the workshop, likely fuelled, after the two ICOMOS structural experts stressed that the risk was real and that the works of BTAP2 would not address seismic vulnerability (or only marginally), something actually written in the last lines of the conclusion of the Method Statement of the contractor [5, p. 39], a document verified and signed by Planarch and BCD progetti. But the fact is that, in most of the technical documents, the conclusions are not straightforward to interpret. To present a measure of the risk –more easily understandable by the various stakeholders– a Bayesian approach may be of interest: evaluating the probability of collapse in the next (5, 10 ...100 years), and looking at how improved knowledge (models, data) may help improving estimates.

In the past, an intervention was proposed to mitigate the risk but it was very heavy, not based on sound and thorough analysis (on the behaviour of the structure and its foundations). This proposal was criticised in previous reports and was rejected by the DGA.

If such a path is to be considered in future, a sounder preparation would be required and a clear understanding of the implications presented to the stakeholders.

The proposal of the consultants address mostly the static structural problem.

The measures they propose on the bottom parts of the shafts of columns (which are certainly critical points) are minimal, will have no or little impact on the structural vulnerability. The reduced section of will not be changed (Figs2.13, 2.15). They are, in our opinion, appropriate given the present state of knowledge and the definition of the project.

The proposal of the consultants address mostly the static structural problem.

The most important is to debate and decide about expectations, values, risks in terms of integrity and authenticity, and intervention options.

To get a more accurate idea about the vulnerability of the structure, reduce uncertainty, and take decisions on firmer bases, a set of actions may be considered:

- Placing accelerometers on the structure to study its behaviour in case of events of small magnitude
- Using the laser scanner data to analyse the deformation of the existing structure in order to better understand what happened during the past earthquake (example of representation:
Complement this study by an analysis of the pathology created at the interfaces between the drums and other blocks.

Facilitate access to the available data (geometry, materials) to promote external studies or create a dedicated multi-disciplinary platform to study the question and its implications (it is not only a technical problem).

Improve knowledge about vulnerability and behaviour, through mathematical modelling.

Study possible intervention options.

To reduce the risk of loosing values, in the present context, and as unsatisfactory as it may appear, it is recommended to take advantage as much as possible of the opportunity offered by the presence of scaffolding to document the structure in each of its dimensions.

### 2.2.2 Local stability problem

With the installation of the scaffolding last year it became possible to approach areas which before were either invisible, either only observable through binoculars (Figs 2.17, 2.18).

It was discovered that the condition of the architraves in between the columns is worse than what was and could be expected from the preliminary inquiries made at ground level.
A more precise assessment of the quality of the stone was possible, and it was not very positive (Fig. 2.19).

As it is normal in any intervention on historical structure some inquiries become possible only when works start. Often they reveal new information about the fabric which require re-assessment about the works and the priorities. That may require some flexibility of the partners. The workshop revealed some tensions between the partners in that respect but solutions satisfying to all parties and for the best interest of the monument are not impossible to find. Key elements of decision are (1) where risk has and can be reduced and (2) the opportunity of the presence of the scaffolding.

The critical point is the safety of the architrave in between the columns.

From the documents that we received before our arrival in Lebanon, it appears that there is not yet a clear understanding of the extend of the problem and of the solutions to reduce the risk affecting these areas.

The discussions that we had on the site with the consultant and the contractors were constructive and
we felt that everyone was very qualified and trying to find a solution sufficient and in the spirit of minimal intervention.

But, in our opinion, this is not enough.

From our observation of the situation of the architrave, it appears that the condition is not the same everywhere. Some areas are in stone, others in concrete. Some areas are very fractured (Fig. 2.21), other less. Some points were anchored to higher levels but because of the fragmentation, these are likely not to be sufficient. In order to try to keep the intervention minimal the situation needs to be studied in greater detail.

This does not mean that other type of work, the killing of the lichen for instance cannot start in parallel.

There is more than one reason to improve the study on these areas:

- The most important is to prepare a sufficient and minimal intervention.
- Present the data in a clear and understandable form allowing the stakeholders to be part of the decision process and share the responsibility about the decisions.
- One of the problem is to understand exactly what was done by the French in the 30s. In other places on the site, it is also not easy to understand the details of the interventions of Kalayan. Let us not make the same mistake. The new interventions should be clearly defined: what are the problems? how they are addressed? The details of the interventions have all to be documented.

The key point is, for each part, to define what part of the structure is at risk (how big are the block which may be unstable) and to propose a set of interventions to address the various types of problems according to their gravity.

In some areas, a long arch-shaped fracture is forming in the architrave, pointing to the risk of collapse of large block fragments under these fractures. In other areas, only smaller fragments seems to be at risk. We recommend:

- Preparing transversal sections indicating what is known about position of the blocks, materials, construction details, reinforcements. Understanding that this can only be made up to a certain point because of practical problems. Sections were prepared by the contractor but they need to be completed. Historical photographs could be used in a more systematic and quantitative way to understand the extend of the

Figure 2.21: Soffit of the second westernmost architrave of the Temple of Jupiter (North on top). Compare with Figure 2.17. Smars, 2018
French repairs, the position of the rebars, etc. The photographs of the North side of the architrave could for instance be used to define the extend of the integration interventions on this side. On one photographs, it is also visible that a man is taking notes during the casting of the beam. Were all the measures taken to trace historical drawings and notes taken?

- Actualisation of the survey, especially the fractures on the soffit and sides of the architraves, looking at which 3D parts of the structure they put at risk.
- Studying and documenting the deformation of architrave (in planimetry and altimetry) may help to identify what happened during the earthquake and which are the stones likely to have been more stressed and fractured.

It is likely that new anchors, of smaller sections, of length, density and orientation decided on the base of a better understanding of the size and nature of the fragments at risk, will be necessary. Fibre anchors may be more appropriate than metallic ones in the present context.

### 2.2.3 Metallic elements

Finding the position and the shape of metallic elements in such a massiveness is not an easy task. Which acknowledge that this work is started and already provides useful information. There are still nevertheless many questions which are not answered and some of them probably be answered and reduce uncertainty about some specific risk (and provide interesting and important information about the construction).

We recommend to:

- Add information about the instruments which were used to investigate the position of the metallic elements, their specifications and the investigation process,
- Put the information already surveyed on the survey, with precise levels and not only in relation to the scaffolding (possibly useful in the present context but not after),
- Extract a few pins to: define their dimension, orientation and control the corrosion Have a sufficient number of them to get an idea about the variations, The logic behind their placement is not always clear (it was not documented),
- Indicate what is in bronze, what is in iron, what is in steel,
- Indicate what is Roman, what is French,

### 2.2.4 Consultants reports

- As in our previous reports, we regret the lack of clear references on the front pages of the documents, in particular the absence of date
- Insufficient synthesis: the non-systematic use of a common terminology is a symptom of this lack of synthesis, the sometimes emotional reaction of the stakeholders is another. The studies presented by the consultant could be more clear. They should have a presentation of the situation, of the objective, of the options, of how a solution was chosen and a conclusion. When one problem is tackled, it should be thoroughly studied and coherently presented. This is for instance the case of the metallic elements discussed above.
- It is in particular not always very clear how the investigations made may affect the course of action: the coring at the base of the columns for instance.
- Endoscopic information should be on sections, movies or picture are not the best way to understand results. It would be more useful to have section on the survey with indication of the position of the cracks, allowing a synthetic view of the cracks and their implication on the structure.
Section 3
Archaeological site of Baalbek – BTAP I

3.1 Introduction

The Progress Report prepared by UNESCO [15, pp.156–163] gives a clear and concise view about:

1. the recommendations we made about the proposed structural interventions at the occasion of the UDAS 1 and UDAS 2 workshops, synthesised in the reports [2, 3].
2. the decisions taken by DGA-CDR and the final interventions.

For some structures, the decisions taken by DGA-CDR are in line with our recommendations (Bacchus Temple, Northern Exedrae, Arab Tower, Peripheral Walls), in other cases the decisions are partly in line (reconstruction of the NE Vaults of the Hexagonal Court, Propylaea).

In the present report, we are not going to repeat the list of arguments given in our previous reports (interested readers may refer to the original documents to understand our point of view).

From the UNESCO Progress Report, it seems that the main argument for cancelling some of the interventions was the lack of resources for additional studies. There is two ways to look at this argument. The positive way is that it was recognised that no intervention should be decided without solid studies. We are obviously very happy by this outcome in line with international standards. The negative way is that, in the long-term, it may not be enough. In our reports we also wanted to stress that, for a large and important site like the archaeological site of Baalbek, it is important to create a long term dynamic to:

- clarify the general objectives of the structural interventions (in a platform where all stakeholders have the chances to express their opinion about threats and values),
- continuously improve knowledge about hazards and vulnerability of the structures [27],
- develop a system to monitor the condition of the structures, the threats (posed and faced by visitors and by nature),
- think about facilitating access to the available data to stakeholders and interested researchers (for a question of accountability about the decisions taken on a site with an Outstanding Universal Value, for encouraging peer review on technical interventions, for encouraging new studies (sponsored or not), for disseminating information about a World Heritage Site.

These comments should also resonate in the present context of the works on the colonnade of the temple of Jupiter.

We appreciate that the “intervention details and data shall be presented in the Final Report”. As we have recently learned, such a report was submitted by ARS Progetti in August 2017. It may well be that some points or problems raised below were addressed and answered in it. We apologise if it is the case but we did not receive a copy of the document. At the occasion of the present workshop, we were asked to express our opinion about the structural interventions made in the framework of BTAP 1. The works were checked during the visit(s) at the light of the information available from previous years. If we had received the latest documents about how the works were precisely executed, our assessment may have been more accurate.

In the following two sections, specific comments will be given on the intervention on the Arab Tower (section 3.2) and on the Propylaea (section 3.3).

3.2 Arab Tower – Structural intervention

The recommendation made in our report after UDAS 1 [2, p.34], [15, p.206] to reinforce the tower through reversible, external means was followed [15, pp.136-139]. A new design was prepared [33] and, as stated in our report after UDAS 2 [3, p.30], the intervention principles are correct (more reversible, less intrusive).

[15, Appendix 9: DGA’s comments on the UDAS Consultants Feedback following UDAS-WS02 - Nov.2016]
The added metallic bracing is clearly visible from the top of the Jupiter Temple (Fig. 3.2, a place where tourists are unlikely to go) but remain relatively discreet from other directions (Fig. 3.1). Figures 3.3 and 3.4 give a closer look on the reinforcements.

Is there a comprehensive document presenting the structural interventions as executed, similar to the report presented by the contractor for the conservation of the surfaces? The Progress Report prepared by UNESCO (and its 9th Appendix, prepared by the DGA) contains useful information. This document also makes reference to monthly reports of Ars Progetti. Their final report of August 2017 mentioned above probably contains greater details and a synthesis of the approach followed. From our points of view, and as reported in [15, p. 137], some questions are not yet answered and it is important to have a precise description of the works.

In the report of UDAS2 [3, p.30], it was recommended to monitor the differential settlements of the structure. The occurrence of settlements was a (long-term) concern. It does not need to be a complex and expensive operation. To quote our report, “Fixed targets (enough to identify eventual settlements) could be fixed in a low area of the tower and their level controlled every 6 months or (…) every year). Even if regular controls cannot be implemented, targets could be used to confirm or refute a diagnosis.”. We used this approach in the past to control the differential settlements of a church (possibly inspired by the good data available for the tower of Pisa). Since the targets were installed in 1994, measures are regularly taken (with the slow path common to many real-case situations), bringing new insights on the long-term behaviour of the structure. This approach may also be implemented in other places of the site of Baalbek. The laser scanner data (and the possibility to compare it with new measurements) offers the possibility to study the long-term behaviour of the structures. This can be complemented by the placement of simple, small targets at critical position which can be measured with good accuracy (and repeatability).

Concerning the mathematical modelling strategy, from the documents in our possession, and the questions left open [3], we may once again regret that the process did not follow the recommendations of the ICOMOS charter “Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage”:

“No action should be undertaken without having ascertained the achievable benefit and harm to the architectural heritage, except in cases where urgent safeguard measures are necessary to avoid the imminent collapse of the structure (e.g. after seismic damages); (…)” [37, article 1.7]

In particular, we do not find clear answers to the following questions:

- What was the vulnerability of the structure before intervention?
Some contingencies may explain what happened for the Arab Tower (and to the Propylaea), and we personally believe that, in the specific case of the Arab Tower, the outcome would not have been different but we hope that our comments, of an important and general nature, will have some effect on future structural interventions.

The rubble masonry of the *tas-de-charge* was unstable. Fragments could fall (Fig. 3.5). The masonry was repointed and capped and, as recommended, the voussoirs were not moved (Fig. 3.6).

### 3.3 Propylaea – Structural intervention

The final intervention [38] is certainly an improvement in comparison with what was first proposed.

But, in continuation to what was said in the previous section about the necessity to “ascertain the benefit and harm” of an action before an intervention, we are really not sure that, if such analysis had been conducted for the Propylaea, the outcome would have been similar (Figs. 3.6-4.1). In our opinion, it is a case where structural, accessibility and readability problems were not analysed together (as recommended before [2, p. 31]) and that, consequently the...
potential stabilising moment is made. The moment provided by gravity can be estimated as 389 kN m as a first step in what is likely to be a pseudo-dynamic analysis. In that case, the structure is clearly unstable. So, it probably means that another type of analysis was conducted, dynamic probably. Which type? This is not specified in the report. Strange, because it is not as easy and it is surprising that, in that case, the effort was not documented. The question has then to be solved with the half page of evidence provided. Looking at the diagram, it seems that a linear distribution of stress is assumed (on the corbel for sure, and between the stylobate and the pedestal in a first guess). The maximum stress on the edge of the corbel is \( \sigma_m = -2.04 \text{ MPa} \) (compression), that would mean that on the other edge of the pedestal, the stress would be:

\[
\sigma_M = \frac{-2.04 \text{ MPa} - 1.6 \text{ m}}{0.17 \text{ m}} 1.53 \text{ MPa} + 2.04 \text{ MPa}
\]

Or 2.76 MPa, a high and positive value, something clearly impossible. So, new hypothesis: "the stress distribution is triangular on part of the base" (0.68 m as it would turn out). The average stress would then be \(-1.02 \text{ MPa}\), giving then a total vertical force of more than 1 MPa, about 2.2 times the weight of the structure. For sure, if the structure rocks, there would be an impact, but then why this distribution? A new hypothesis is needed: "the stress only acts on the corbel". In that case, the total vertical force becomes:

\[
W = 0.17 \text{ m} \times 1.6 \text{ m} \times \frac{1.53 \text{ MPa} + 2.04 \text{ MPa}}{2}
\]

\[ W = 486 \text{ kN}, \] the exact weight of the column and a sign that this interpretation is correct. But why the whole force would need to be concentrated on the corbel? Is that to find an upper-bound to the force which may act on the new structure and help sizing it? Probably not: all the weight could be concentrated on the edge, impact could mean higher vertical load and earthquakes have also vertical components. Leaving this this point aside, the moments can be considered. Three forces are acting on the structure: the weight of the column (+ architrave) 486 kN, the reaction from the corbel 486 kN, in the opposite direction, and the horizontal force of 97 kN. The first two, create a moment:

\[
M_S = 486 \text{ kN} \times (\frac{1.6 \text{ m}}{2} - \frac{0.17 \text{ m}}{2.1})
\]

This is 349 kN m, much less than the 869 kN m of the overturning moment, and not surprisingly less than the upper bound of 389 kN m mentioned above. According to this new calculation (pseudo-dynamic again), the structure is also unstable. So, what is its meaning? Is it to ensure, that in the event of the
collapse of the columns, the corbel will not fail? This sounds strange. A first reading, it seemed that the intervention was designed to give to the structure the ability to resist to an earthquake with a PGA of 0.2 g. Is that a misunderstanding?

In the discussion above, some steps (not verbally expressed) may have been missed (and five explanation sentences may have precised the hypotheses and the process, and facilitated the work of the reader).

But possible mistakes do not invalidate the main point: it is important to state precisely, in terms as simple as the context permits, with appropriate level of details, the hypothesis and the process of evaluating structures. These unpleasant comments could possibly have been already made in [3], if the documents had not arrived only a few days before the 2nd UDAS Workshop.

The structural calculations made for the Propylaea were taken as an example but similar comments could be made (in greater length) with most of the structural evaluations of BTAP 1 and BTAP 2 received. If the idea of the reports is to demonstrate that an intervention is right, it is my opinion that not enough details are given. If the idea of the reports is to illustrate an intervention decided only on trust in the designers or contractors, then things are different.

To be clear, it should be repeated that, from a structural point of view, the intervention undoubtedly improves the safety of the structure. The comments above refer to the process followed (timing, decision making, reporting . . . ), which should be improved.

A final question about the detail of the intervention. How was filled the large gap between the console and the pedestal of the column (Fig. 3.11)? There were discussions about the matter during UDAS 2 but it seems, according to the Progress Report [15, p.142], that the design changed and that non-shrinkable cement mortar was used instead (Fig. 3.12, [15, p.142, Figs 307–311], as it was actually specified in [38]). It would be useful to get more detailed information about the intervention in a final report.

### 3.4 Bacchus & Venus temples – Surface conservation

We would like to remind what was stated in our final report of 2017 [1, p.30]:

- A complete documentation is compulsory! We stated last year that on-site documentation is always compulsory for conservation works, and we have strongly advised the mapping of the interventions and a detailed description of the materials used, their quantities and compositions.
- As part of a good management focused on fulfilling quality requirements, we advise to prepare...
procedures intended to ensure that the quality of the restoration is maintained. These procedures of monitoring should be implemented as quickly as possible.

- By the fact that the structures are consolidated, life span is not "frozen": materials continue to change and to react to environment! So, in order to preserve we strongly advise a preventive conservation approach by establishing an urgent complete program of maintenance (for daily maintenance and for seasonal and annual maintenance). This program should include the type of actions, needed materials, needed capacities, etc.
Section 4

Archaeological site of Baalbek - Site presentation - BTAP II

4.1 Archaeological site of Baalbek

While discussing site presentation, one cannot forget that the archaeological site of Baalbek is composed by various sites that make part of one historical unity but that are nowadays divided by the modern urban settlements (ex: Boustant al-Kham, roman quarries area Hajjar al-Hible...). We have often the impression that the site presentation is not really taking into account this component.

The relation between the various archaeological areas is of great importance (Fig.4.4). An example of this is the landscape and visual relationship, almost completely destroyed, between the temple of Jupiter and the quarry area Hajjar al-Hible (Fig.4.3). These issues should be evaluated and revised. Moreover, as already stated in previous reports, the boundaries as they are established nowadays should perhaps be revised to give to the site a sufficient size and appropriate configuration to facilitate sustainable resource protection and enhance visitor enjoyment, taking into account current historical viewpoints and historical urban landscapes.

4.2 Western Jupiter Colonnade bases

As the main problem in this area is security, the backfilling is recommended, to the profiles stabilisation and the preparation of the path walk to visitors. Instead of positioning the column bases in a kind of alignment recreation (with original elements not in their original position), we proposed in our report of 2017 [1, p.33] to revise and perhaps develop another type of approach, possibly with a treatment of the ground surface showing the position of the colonnade using negative imprints.

The original blocks from Jupiter temple that are scattered on the site, near the basement of the temple, could be relocated all together in order to create an exhibition, and form a kind of lapidarium. The architectural elements are of great value. To enhance their presentation is certainly an improvement. Care and respect are clearly needed. An important point to take into consideration is the advanced level of damage of these architectural elements. They should be consolidated before any transport. Their present condition must be assessed and a conservation program implemented.

4.3 Path around the site

As stated in our report on 2017 [1, p.36] we would like to draw attention to certain details. From the documents received, it is difficult to understand the technical and aesthetical solutions for details such as: changes in floor levels, links between horizontal path levels with ramps and steps, relation between new paths and original or existing features, etc. (Figs4.5, 4.6). Moreover, the boundaries of the paths should
Figure 4.3: Visual relationship between the quarry area Hajjar al-Hible and the temples of Jupiter and Bacchus. Patrício, 2018

Figure 4.4: Explanation panel in the quarry area Hajjar al-Hible. The land morphology was an essential element for the carved stone transportation. Smars, 2018
be treated in order to reduce visual impacts.

One must pay attention to the access to the site, and to different areas, for emergency personnel and cars (firefighters, medical personnel, ambulances).

The reorganised area in front of the Propylaea of the Jupiter Temple, should be as soon as possible planted. The current situation does not constitute an improvement for the reading and comprehension of the original remains (Figs 4.1, 4.2). Therefore, the plantation should be prepared carefully, taking into account the weather characteristics of Baalbek and the aesthetical integration of the entrance.

Moreover, we advise revision of the intervention on the North side to permit the use of the dependency door (Figs 4.7, 4.8).

In addition, we draw attention to the surroundings, a little abandoned. As an essential part of a management plan you have to look at the presentation of the site as a whole.
Section 5
Final notes and recommendations

5.1 Jupiter temple colonnade
- Many of the original blocks from Jupiter temple are scattered on the site, near the basement of the temple. We recommend to study in detail all these architectural “member disjecta” and to proceed to their restoration.
- During the visit, we could see an extraordinary example of Roman architecture with very interesting details. We strongly recommend to develop a detailed architectural study of the colonnade (colours, construction technique...). The presence of scaffolding is a unique opportunity. It is also an insurance to secure information elements which may deteriorate or disappear. In that way, it helps reducing risks (loss of information is also a risk).
- All interventions should be monitored and documented during the works.
- Regular control and maintenance will need to be planned. Think and possibly facilitate future access to the upper parts of the structure when the scaffolding will be dismantled.

5.2 Stone conservation of Jupiter temple colonnade
- Problems should be tackled globally, looking and treating the stone blocks in their totality, in theirs mass;
- The mapping of degradation patterns should continue and be updated as the works progress;
- The method statement should be updated;
- The iron pins and of the consequences of the existing rust in the stone core should be better understood;
- A detailed report on mockups, their results, choice process and interventions should be prepared; an inventory of trials and procedures specifying exactly which materials were used, in which proportions, solutions, following which application methods and describing the outcome (being positive or negative).
- We recommend the revision of the lichens cleaning procedure, thinking carefully at its consequences. It should then be decided in collegiality whether lichens should be removed or not. Laboratory analysis are advised to verify the effectiveness of the biocide.
- The application of chemical patches (chemical cleaning by mean of soaking, as ammonium carbonate) should be avoided.
- Micro-sandblasting is necessary but should be avoided on fragile carved decoration.
- In general, for pointing we advise mortars that are less resistant, more flexible, more capillary and more permeable than the original stone, in order to privilege the (future) deterioration of the repair material.
- We strongly recommend to develop a detailed architectural study on the columns and the entablature.
- All the interventions during and after the works implementation should be constantly monitored, especially during the cleaning procedure.

5.3 Structural conservation of Jupiter temple colonnade
- The fact that the seismic vulnerability of the structure is not going to be significantly mitigated by the works as they are scheduled does not invalidate the importance and relevance of the other actions planned in the framework of BTAP 2.
- The intervention to consolidate the architrave of the colonnade of the temple of Jupiter is important and should be implemented (section 2.2.2). Its current condition presents a clear danger to the visitors.
  - But there is not yet enough information to start the work.
  - The condition of the architrave should be studied in greater detail. This should not require too much time and could be implemented in parallel with other interventions.
  - A set of actions should be devised to stabilise fragments of small to bigger size. It is likely to require measures of incremental invasiveness, enough to be effective, but within the respect of the principle of minimal intervention.
  - A detailed strategy should be approved before the work starts
  - The intervention on the architrave should be documented in detail, and updated as the work proceed.
- A long-term dynamic should be launched to deal with the seismic risk (clearly for the columns of...
the temple of Jupiter but the process is beneficial to the whole site). See section 5.3.1

- Clarify and define the objectives and the limits of the structural interventions.
- Improve knowledge about the structure and all the elements which contribute to its value,
- Develop a monitoring strategy to bring information about behaviour of specific structures, facilitate maintenance and help prioritisation,
- Facilitate access to data,
- Organise a structure for the stakeholders to meet, discuss and inform,
- Proceed with an intervention only if the vulnerability before and after the intervention is evaluated, and its benefits and harms on all the values have been weighted.

● Reports should:

- Give enough information about methodology, objectives, limits, process. See section 5.3.3
- Address the actual problems faced by the structures, as they appear as the works proceed. If they are commissioned to external entities, they should be completed by the commissioner to provide information about their aim and how their conclusions influence the project. How did all the investigations made on the columns affected the course of actions? How did the course of actions (discovering the bad condition of the architrave) affected the investigations?
- Be understood not only as necessity of the moment but also as documents escorting the monument in its life, a piece of a monitoring strategy.

5.4 Site of Baalbek

Ensure the permanency of the interventions and the durability of the archaeological remains!

Experience shows the difficulty of maintaining, in the long term, the interest and the commitment of the managers as well as that of the public. The capacity of the management teams to actualise the cultural message is not obvious and this adjustment requires the involvement of all stakeholders well beyond the enthusiasm of the results of a punctual intervention. For example, the considerable effort made for the restoration of the Bacchus Temple and for the Venus Temple, give a good illustration of these new necessities. It is about adapting the discourse, to the evolution of social and cultural tastes and practices: It is realised that the “current” management of sites, once assured their study, preservation and enhancement, cannot do without the regular mobilisation of scientists. It implies proximity management and continuity of public or private investments (communities, foundations, associations), conditions that are difficult to meet. This is probably the most difficult challenge.

This presupposes the design and implementation of a framework and of a suitable management system. This requires the establishment of surveillance regulations, programs and activities adapted to sustainable management. As stated by the new ICOMOS orientations “Salalah guidelines for the management of public archaeological sites” [39], management plans and its implementation must concern not only the site itself but also its immediate surroundings and the region as its development plan is linked to the visits. These Guidelines provide a roadmap for the identification and development of a framework and an effective management system, as well as the necessary improvement of those already in place. Therefore, we would like to emphasise a few points of interest for the future of the archaeological site of Baalbek.

● To work on the totality of the archaeological site and not only on the Jupiter temple area.
● Ensure that a well-documented Atlas following internationally recognised best practices is implemented. As the number of documents concerning degradation (from the various restored structures) is very large, we recommend to prepare a Degradation Atlas (mapping + decay descriptions + photographs + applied methods + results) for the site.
● We recommend to prepare a data base concerning all available historic documentation.
● As inventory and evaluation of cultural resources is the first step in establishing the feasibility of developing a sustainable management system for archaeological sites, we strongly advise the preparation of an evaluation of the totality of the site (Boustant al-Kham, together with the roman quarries area Hajjar al-Hible) addressing vulnerability and threats as well as to address the needs for mitigation of for preventive actions.
● Every effort should be made to develop a detailed evaluation for the protection of cultural and natural resources, such as the identification of the various archaeological elements and archaeological landscapes existing in Baalbek. Moreover, the site boundaries and management zones should perhaps be revised as the site

“should be of sufficient size and appropriate configuration to render sustainable resource protection and visitor enjoyment possible and likely (tak-
ing into account current and potential impacts from sources beyond proposed boundaries)" [39, section 1.2.2, Site size and configuration].

- We recommend to work in a near future on interpretation: virtual reconstructions of temple and the complex (context, building construction, object...); visualisation issues (how to represent uncertainty reconstructions). To develop 3D documentation of the site, a 3D scientific visualisation of the temple together with a digital library.

- A detailed Monitoring program must be prepared for the totality of the archaeological site and for the various restorations. The program should specify the technologies, the protocols, the instruments, indicators, and standards that should be followed. The priorities of monitoring should also be defined.

- We also advise to implement a monitoring system to all restored structures (for colour integration, fissures and shrinkage, discolorations...).

- As already stated many times in our previous reports [2, p.1, 9, 21] [40, p.7, 39] [1, p.37, 38], a periodic maintenance plan is compulsory for the good preservation of the site elements.

- We strongly recommend to work on publications of the restoration works.

- To conclude a usable and a real operational General Management Plan should be prepared and implemented respecting the essential elements and setting out the framework, structure, system, policies, actions (schedules, indicators, and budgets). Following what already stated the management plan should include a risk assessment and a maintenance programme.

The first goal of the GMP should be to ensure the preservation of the site’s integrity and authenticity by the application of the 4 functions that span across all restoration projects: planning, organising, leading, and controlling. Four functions, where each step builds on the others, to create an interface between management and conservation strategies.

We encourage to intervene as less as possible on sites and remains.
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