



MEDISTONE

Preservation of ancient Mediterranean sites in terms of their ornamental and building stone

Newsletter n°3 January 2007

Editorial

Welcome to the third issue of MEDISTONE Newsletter. BRGM as co-ordinator of the MEDISTONE project, launches in the name of the consortium a newsletter to inform about the aims and the work under progress of the project.

MEDISTONE project (call FP6-2003-INCO-MPC-2 ; contract n°015245) proposes to contribute to the knowledge and the conservation of three of the most important archaeological sites in North Africa (Volubilis in Morocco, Djemila in Algeria, the Alexandria Lighthouse in Egypt) :

- identifying stones used and determining their origins in terms of geographic areas and, if possible, the former quarry sites
- establishing diagnosis of the state of conservation of the stones, and describing mechanisms of the deterioration to stone for semi-arid continental climate
- providing answers to the main problems regarding stone conservation / restoration that are liable to be met at the selected sites i.e. reassembling fractured and fissured stones.

The present issue is the occasion to give a summary of the works performed during the first year of the project (from January to December 2006).

It also includes a focus on the two Italian partners involved in MEDISTONE, i.e. LITHOS and the University IUAV of Venice.

This newsletter is part of MEDISTONE ongoing dissemination activities. All partners are acknowledged for their contributions.

David Dessandier, co-ordinator, BRGM

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Works performed during the 1st year of the project

During the first year of the project (from January to December 2006), the major achievements of the project may be highlighted as follow.

WP1: Identification of stones and determination of their provenance

For each of the three sites a preliminary phase for collecting the geological, topographic and architectural documents available as well as reviewing the previous articles dealing with the sites was done. If numerous data about archaeology and history of the sites were consulted, very few documents about their ornamental and building stones were found.

VOLUBILIS SITE (MOROCCO)



Photos 1 & 2

Concerning Volubilis, a first field campaign during May 2006 dealt with a visual description and identification of the main types of building stones (various limestones) and decorative stones (marbles *sensu largo*) and to collect representative samples for in-laboratory characterization (microscopic study of thin sections, X-ray diffraction, identification physical tests, isotopic analyses...). Parallel to Volubilis site investigations, a preliminary search for ancient quarries that could have supplied the site with stones began in surrounding area. Different quarries were located, visited and sampled. According to decorative stones, all the excavated areas have been carefully explored for the presence of stones different from local ones and of true marbles. Each single house and the most important monuments have then been inspected and selected fragments of the mentioned stone materials taken for analysis. In general, from what has been observed in situ, a very limited amount of marble s.l. species has been noticed (Photos 1 and 2). To carry on study of decorative stones from Volubilis, a second mission during September 2006 on Volubilis and Rabat was performed to sample some white marble objects and column exposed at the present time in the archaeological museum of Rabat and some of the marble objects collected during the excavation and stocked in the storerooms of the conservation of Volubilis. The search of traces of ancient quarries by the mean of a detailed study of geological data available and of a systematic exploration of Volubilis region outcrops was also carried out during the first period of the project. All these preliminary visual results concerning both building and decorative stones of Volubilis have to be confirmed and achieved by the in-laboratory analyses still in progress.

ALEXANDRIA LIGHTHOUSE

Concerning Alexandria Lighthouse, it has to be reminded of the Lighthouse toppled into the sea and today the site is essentially underwater just off the coast of Alexandria, occurring at depths of between 6 to 8 meters. The ruins of the lighthouse consist of about 2500 blocks of architecture or sculpture lying on the seabed. Undersea excavations (leaded by Centre d'Etudes Alexandrines) undertaken in QaitBay since 1994 permitted to extract from under the sea about fifty blocks of different sizes. The majority of them were cleaned and desalinated before to be exposed in different open-air areas in Alexandria.



Photos 3 & 4

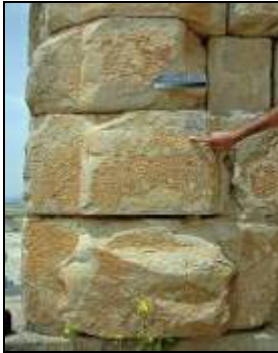
In the framework of MEDISTONE, a first field campaign during July 2006 permitted to visit QaitBay fortress (supposed to be built in the place of the collapsed lighthouse and using its ruins) and to proceed to an overall examination of the different sites of storage / exposure / exhibition of the lifted out blocks (cf. Photos 3 and 4). In general, the stones examined are present in a form of columns, part of columns, large blocks, small blocks, statues and obelisks. They are formed either of rose granite, granodiorite, marble (rare), recrystallized limestone, graywacke, quartzite and silicified sandstone. During a second campaign in September 2006, a detailed study of the blocks exposed in the previous selected sites was carried out with the aim to inventory the main types of the building and the ornamental stones related to the lighthouse. In addition, most of the blocks were sampled for in-laboratory characterisation (petrography, mineralogy, chemical characterisation, identification of physical properties and isotopic analysis) still in progress. Parallel to the study of building and ornamental stone blocks exposed in Alexandria, the search of ancient quarries began with the study of al-Max – Abu-Sir area (western Alexandria) indicated in a previous work as quarries used for the lighthouse construction. “Old” and “modern” quarries of both of the sites were visited and sampled. As most of the stone related to the lighthouse are still existing underwater and thus not easily available for study. Cooperation between the MEDISTONE team and the archaeologist of Centre d’Etudes Alexandrines took place, and resulted by providing for the present study many samples collected from the stone blocks existing underwater site, during their diving season in September & October 2006. The collected samples from the stone blocks in different sites at Alexandria as well as those collected from the underwater sites were sent to European Partners at the end of 2006 for In-laboratory characterisation still in progress.

DJEMILA SITE (ALGERIA)

Concerning Djemila (ancient Cuicul), the first field campaign during November 2006 permitted to make a visual description and identification of the main types of building stones (various limestones) and decorative stones (marbles sensu largo) and to collect representative samples for in-laboratory characterization (microscopic study of thin sections, X-ray diffraction, identification physical tests, isotopic analyses...). The on-site archaeological Museum of Djemila and its storages that assemble very numerous marble s.l. objects (including a little marbles collection) or fragments were studied and sampled. Parallel to Djemila site investigations, a preliminary search for ancient quarries that could have supplied the site with stones began in surrounding area. Different quarries were located, visited and sampled. According to decorative stones, coloured marbles were identified macroscopically while selected fragments of the white/grey marbles as well as of stone materials of uncertain origin were selected and sampled. As in the case of the site of Volubilis, a limited amount of imported marble and stone species has been observed in situ or as roving materials. The different identified varieties are of Greek origin, from Asia Minor (Turkey) and from North Africa (Algeria and Tunisia). Concerning the identification of the white and greyish crystalline marbles, the presence of Greek white marbles is suspected as well as that of “local” ones. A preliminary search of corresponding Algerian marble ancient quarries was undertaken, visiting and sampling “Cap de Garde” ancient quarry in (near Annaba), and Aïn Smara quarry (near Constantine).

WP2: Diagnosis of the conservation state of the stones

VOLUBILIS SITE (MOROCCO)



Photos 5 and 6

According to Volubilis, the work began with a bibliographic research on the site and its environment undertaken. Then, during the mission of May a detailed survey of the site listed the various degradation features on the different types of stone recognised by the WP1 group. Photos were taken at different scales in order to make the guide of main degradation features. Three main active different natural degradations were observed : a thin desquamation phenomena affecting the grey and hard building limestone, a granular disintegration affecting the yellow and soft limestone and an orange patina visible on many walls and sculptures of the site (cf. photo 5). Consequently, it was decided to focus in-laboratory research work on two main topics :

- the understanding of the origin and formation mechanisms of the orange patina (ancient treatment, biological and/or chemical weathering or deposit?)
- the evaluation of the role of soluble salts, clay minerals and climatic thermo-hygric variations in the superficial detachment of stones (desquamation, granular disintegration).

A part of the north wall of the basilica of around 20m² was selected as representative area for the mapping (cf. photo 6) and the description of the degradation features. Two grey hard limestone stones of this wall showing fissures were selected for both WP3 restoration work (reassembling) and degradation features mapping at the scale 1/2. A pillar of a gate in a villa built with the soft yellow limestone, showing desquamation, granular disintegration and fissures was also selected and mapped (1/5) for deeper investigations in relation with the work of the WP3 (reassembling). The general map is now available and documented with more than 60 different degradation patterns. Twenty samples (powder, scales...) were also collected for In-laboratory analyses in progress.

ALEXANDRIA LIGHTHOUSE

About Alexandria lighthouse, the first field campaign during July 2006 permitted as for WP1 to the partners involved in WP2 to visit QaitBay fortress (supposed to be built in the place of the collapsed lighthouse and using its ruins) and to proceed to an overall examination of the 6 different sites of storage / exposure / exhibition of the lifted out blocks. Then, documentation and various information concerning the excavations, the restoration work (desalination, repair, cleaning...), the state of conservation undersea and the history of each sculpture were collected. A preliminary overview of the state of conservation of each sculpture and architectonic element was done. Many various kinds of degradation feature were observed with different possible origins and mechanisms (weathering during Antiquity, undersea alteration, current weathering). Among the samples collected on desalinated or not desalinated sculptures during the second campaign of September 2006, ten were selected for deeper investigations (still under progress) on :

- Chemical, biological and physical alteration due to the sea-water on the different stones.
- Mechanisms involved in the scaling of the Aswan granite (weathering during antique times, sea-water interaction, modern weathering, comparison with fresh granite coming from the antique quarries).
- Impact of marine concretions and their removal on the preservation of the surface of stones.
- Efficiency of the desalination process.

Concerning mapping, several items were selected for deeper observations (general mapping of the degradation features ; in progress) and for future restoration works. The In-laboratory study of the conservation state of some of the samples (not desalinated) collected during Autumn 2006 by Centre d'Etudes Alexandrines among the stone blocks still underwater has recently began.

DJEMILA SITE (ALGERIA)



Photos 7 and 8

Concerning **Djemila**, a detail survey of the site was undertaken during the field mission of November 2006 to list the various degradation features. Views were taken at different scales in order to make the guide of main degradation features. The in situ study showed that fracturation, orange patina and lichen colonization were the main degradation patterns affecting the stones. Deeper investigations were done on the site in order to describe more precisely the degradation features and to collect samples (powder, scales, lichens ; analysis in progress):

- Lichens were mainly collected in the theatre which presented all the different kind of species
- The orange patina (cf. photo 7) was also studied and sampled in the theatre; this degradation pattern is very interesting because also present in Volubilis site;
- Two zones of around 20m² (an arch that threatens to collapse and a West wall along the rebuilt temple of Septimius Severe ; cf. photo 8) representative of the fracturation affecting limestones were selected, documented and sampled with the agreement of both WP2 and WP3 partners.

The detailed mapping (1/20) on the selected wall also began and two stones showing fissures were selected for detailed mapping at the scale 1/2 and for WP3 restoration work (re assembling). Ultrasonic velocities measures on these two stones before any attempt to re-assemble them were also undertaken.

WP3: Development and testing of techniques in the reassembling of fractured and fissured stones

The field-works on the three archaeological sites Volubilis (Morocco, May 2006), Djemila (Algeria, November 2006) and the Light house of Alexandria (Egypt, July 2006) allow the evaluation of the occurrence of the stone-breaking phenomena and confirm indeed the right choose of the research thematic based on re-assembling fractured stones.

VOLUBILIS SITE (MOROCCO)

According to the climatic and environmental contexts of the case-studies, the occurrence of cracks/fractures doesn't show an homogeneous distribution, and has different causes and extent. For example, The contour-scaling of stones is a damage-type often observed on limestone of the **Volubilis** archaeological site. This type of damage drives the sampling. Indeed, a scattered compact-limestone bloc with a an aspect close to the ones of the western wall of the basilica have been collected. An other stone type has been sampled, a soft-limestone, coming from the upper part of the Gallien baths wall. This bloc shows scaling-like damage with layer up to 1 cm thick. This "delamination" seems to be connected to the original mineralogy of the stone, particularly to its clay amount and its sensitivity to water load. In addition to the samples coming from the site, two equivalent blocks of a surrounding quarry have been collected for laboratory tests.

DJEMILA SITE (ALGERIA)

At the **Djemila** archaeological site, the stones have a different fractured aspect. The climatic conditions harder than in Volubilis induce higher stress on the material. The building stones, mainly micritic compact-limestone were affected by several tectonic intrusive phases. The stones show several generations of cracks (mm to cm) filled by carbonate minerals. These veins with a structure and a composition different from the hosting stones represent natural discontinuities where the fractures occur. Other fractures and cracks often parallel to the maximum load, seems to be mechanically generated (the rising-again of the wall). These fractures represent a preferential circulation way of solutions (rain) and are reactivated during frost periods. 2 blocks have been taken from Djemila archaeological site in order to realise iso-dimensional specimens to be used for In-lab tests.

ALEXANDRIA LIGHTHOUSE



Photos 9 & 10

In **Alexandria**, 2 sphinx in exhibition at the open museum Kom El Dikka (near roman theatre) have been selected as preferential object case-study. They are respectively made by pink granite and a dark-compact granodiorite. The main damages of the sphinx granite-made is an exfoliation probably generated by salts re-activated during the out-door exhibition (cf. Photos 9 and 10). Many parts of the granodiorite sphinx are missing and the valorisation of this sculpture with blunting surfaces, don't need cracks filling/padding but a real re-assembling action. The sampling on these two original sculptures is not realistic, that's why the next field-work planned in March 2007 at the Aswan quarry will allow a sampling of their equivalent rocks to be tested in laboratory for adhesion and sealing products previous to sticking/pinning action.

For the filling restoration action, some re-assembling products have undergone lab preliminary evaluation tests. These tests were focalised in practical aspects (consistence, setting, hardening and fissuring) in order to adapt in-fine use of these products to the width of the fractures to be filled. The lime-based products are traditional, and could be made using the local lime to meet the demand during the application in site of the final research finding. The products to be used for the degraded sphinx are commonly used in the stones conservation: Ethyl silicate for superficial consolidation and sticking epoxy resin (some are available in Cairo) for pinning/sticking actions.

Concerning the laboratory study aiming the validation of the re-assembling techniques, it requires large specimens ($2 \times 2 \times 6 \text{ cm}^3$). The first year of the project was focalised on the conception and the set-up of a dilation system able to record small dimensional variations under accurate and reproductive conditions. The equipment is under realisation and already preliminary tests were undertaken on a lime bloc coming from Volubilis site as an ongoing lab-step of the optimisation of the analytical conditions.

For in situ transfer of reassembling protocols of stones fragments, the main action was the selection of the zones where the restoration will take place. In Volubilis, 2 zones have been selected: the first one corresponds to 2 blocs belonging to the west wall of the basilica, which are affected by detachment of small scale (mm).

The alteration of this zone is deeply described in collaboration with the WP2 partners including the mechanisms generation this kind of scaling. The same action is undertaken on the upper part of the wall of Gallien baths made by soft-lime and showing delamination damages. In Djemila site, the selection of the test-zones is also achieved. The choice was based on technical-scientist and feasibility criterion, as well as the urgent need of the preservation of this patrimony in peril. The first zone corresponds to 2 stones highly fractured located on the enclosure wall of the Septum Severe temple. These stones show transverse and longitudinal cracks parallel and perpendicular to the stratigraphic bedding. The cracks are located in the carbonate matrix or oriented along discontinuity planes linked to vein of calcite. The cracks can show locally a high extension with some opening below 0.5 mm. The second zone corresponds to an arch of the vaulted part of the Capitol baths. This zone is also under depth damages diagnosis of WP2 partners. The building stones are highly fractured and the risk of stone fall or a part collapsing is real. A top priority treatment is giving to this zone which will play also the role of a practical example.

Focus on partners

IUAV - LAMA (Italy)



Istituto Universitario di Architettura di Venezia (IUAV), Laboratorio Analisi dei Materiali Antichi (LAMA) :

Established in 1993, L.A.M.A. provides teaching and research facilities within I.U.A.V. and also carries out projects commissioned from outside the Institute. The Director of the laboratory is Lorenzo Lazzarini, who is also Professor of Applied Petrography for the specialist degree course in the conservation and restoration of the architectural heritage.

The main areas of research concern:

- 1) the chemical and physical characterisation of stone and marble and lithoid materials (brick, mortar and plaster) used in buildings of historical and artistic interest, and determination of the decay and alteration phenomena to which these materials are subject;
- 2) archaeometric studies designed to identify the provenance and production and/or processing technologies of stone, lithoid and ceramic materials found in archaeological excavations or conserved in museum collections;
- 3) the study of support and preparatory layers, the identification of pigments, the stratigraphic study of paint and the identification of application techniques in wall and easel paintings.

L.A.M.A. has a unique archive of over 1,500 thin sections of quarry samples of marbles and stones used in antiquity, coming from Asia Minor, Egypt, Greece, etc.. The archives also contain a similar number of thin sections of ancient ceramics and plasters from archaeological excavations and important monuments.

In 2000, L.A.M.A. was responsible for organising the VI International Conference of ASMOSIA (Association for the Study of Marble and Other Stones in Antiquity), held at Palazzo Badoer from 15th to 18th June. Subjects dealt with at the conference included the identification and analysis of stones used in antiquity, the export and use of stone in art and architecture, decay processes and questions of authenticity in connection with ancient stone artefacts.

LITHOS SNC (Italy)

LITHOS Snc was founded in 1985 by three curators with different educational backgrounds and experience in the field of conservation. Their training in conservation was achieved through courses held at The Università Internazionale dell'Arte in Venice, and through ICCROM courses in Rome and Venice, held in association with the Istituto Centrale del Restauro. LITHOS operates mainly on polychrome sculpture and stone artefacts of historical and artistic interest, and is also involved in the conservation of mural paintings, terracotta, gypsum, and plaster artefacts. From 1988 LITHOS began to work on some of the main French monuments for the French Minister of Culture. In 1988, LITHOS, together with other Venetian firms operating in the field of Conservation, formed the: Consorzio Marciano, an association of firms collaborating in a joint effort to challenge, with an articulated and ample organisation, the specific predicaments involved in Conservation Projects in the city of Venice. Since 1991, LITHOS' associates have been consultants for UNESCO, UNDP, ICCROM, Ecole Française d'Extreme Orient, and World Monuments Fund, in International Conservation Projects. In 1992, LITHOS received the Nineteenth PREMIO TORTA, an important Award for the Restoration of Venetian Monuments, awarded to highly specialised conservators operating for the safeguard of the city's historical monuments. In 1995, after having completed a Qualification Course in the use of the Laser Beam in Conservation, LITHOS has acquired a LASER appliance to comply with a more technological approach to particular interventions.

Various Informations

Next planned meeting

- WP1-WP2-WP3 : Field works in ancient quarries in Aswan area (Egypt) during March 2007.
- WP1 : Technical synthesis works about Volubilis site during May 2007.

Next issue of Newsletter

N°4 (May 2007).

Dissemination of MEDISTONE results

Presentations of POSTER or COMMUNICATION planned at the :

- 7th International Symposium on the Conservation of Monuments in the Mediterranean Basin – Orléans, France – June 6-9, 2007.
- 2^{ème} Rencontre Internationale sur le Patrimoine Architectural Méditerranéen – RIPAM2 – Marrakech, Morocco – October 24-26 , 2007.



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