



MEDISTONE

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

Newsletter n°1 April 2006

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Editorial

Welcome to the first 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.

Conservation of archaeological sites around the Mediterranean basin constitutes a major challenge for the future. Hitherto, studies of archaeological sites have tended to lack sustained follow-up over time, and not interacted sufficiently with other similar sites to enhance the results of research. As a result investments and expertise have tended to disappear after completion. Due to the absence of durable conservation practices, increased exposure to semi-arid climatic conditions, increasing pollution, and to ever increasing pressure from tourism, many sites suffer from severe degradation.

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 project involves twelve partners (technical institutes, universities and research organisations, government institutions in charge of cultural heritage i.e. users), five from Mediterranean countries (Algeria, Egypt, Morocco) and seven from Europe (France, Italy, Germany, Greece), having experience in the field of either ornamental and building stone studies and / or the deterioration and conservation of cultural heritage stones.

This newsletter is part of MEDISTONE ongoing dissemination activities. We also invite you to take part of this newsletter and to give us your comments, and contribution for the next issue.

David Dessandier, co-ordinator, BRGM

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Project Presentation

The protection and conservation of archaeological sites represents major challenges for the future and is a major responsibility for our current generation. Many studies of archaeological sites have hitherto tended to be limited to specific objectives but were not necessarily planned within a framework of sustainability. As a result investments and expertise fade away after completion of such studies. Due to the absence of a durable conservation objectives, an increased exposure to semi-arid climatic conditions, increasing agricultural and industrial pollution, and to pressure from tourism, the sites are suffering from intensified degradation with respect to the conditions of their original discovery and excavation.

Three prestigious archaeological sites, two listed within UNESCO's World Heritage List, have been strategically selected for the current study. This selection has been based on priorities for site preservation and tourism indicated by the participant non-European partner countries and on the presence of an emphasised scientific challenge and possible breakthroughs for site preservation technologies identified by the included EU partners.

Two archaeological sites in neighbouring non-European Mediterranean countries, flourished in ancient times between the 2nd and the 6th century AD,: Volubilis has been listed by the World Heritage Committee since 1997, "considering that this site is an exceptionally well preserved example of a large Roman colonial town on the fringes of the Empire"; and Djemila has been listed since 1982, "bearing a unique testimony to a civilisation which has disappeared and being an outstanding example of an architectural ensemble illustrating a significant stage in human history". The third site, the Alexandria lighthouse, is one of the Seven Wonders of the Ancient World. It was initiated around 290 BC and served Mediterranean navigation until AD1480, when a medieval fort was built by the Sultan using the original marble from the lighthouse, illustrating the re-exploitation of these cultural monumental buildings.

All three sites demand further study in order to better know and preserve the roots of our civilisations. Characterisation of the stone at the sites, used in ornamentation and building, and in particular its provenance, to further support / restore the sites and to durably preserve them whilst allowing exposure to tourism, is fundamental. Provenance studies will not only help to locate the best materials for restoration, but will also allow investigation into ancient trading / transport routes in the waning stages of the Roman Empire (e.g. some material at Volubilis may have been traded / transported over distances of two to three thousand kilometres).

The MEDISTONE approach will face the above two-fold problem characterised by the absence of sustainable studies combined with intensified site degradation, and will be based on the three following work axes :

- Identification of stones and determination of their provenance (work package WP1)
- Diagnosis of the conservation state of the stones (WP2)
- Development of appropriate conservation / restoration techniques (WP3).

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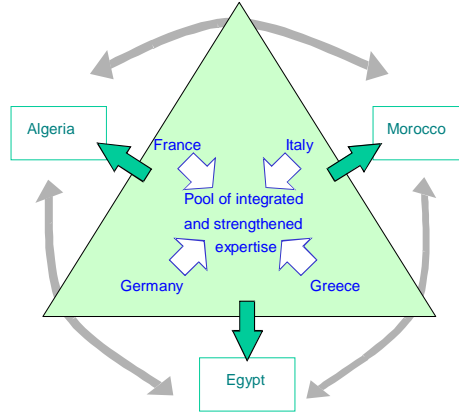
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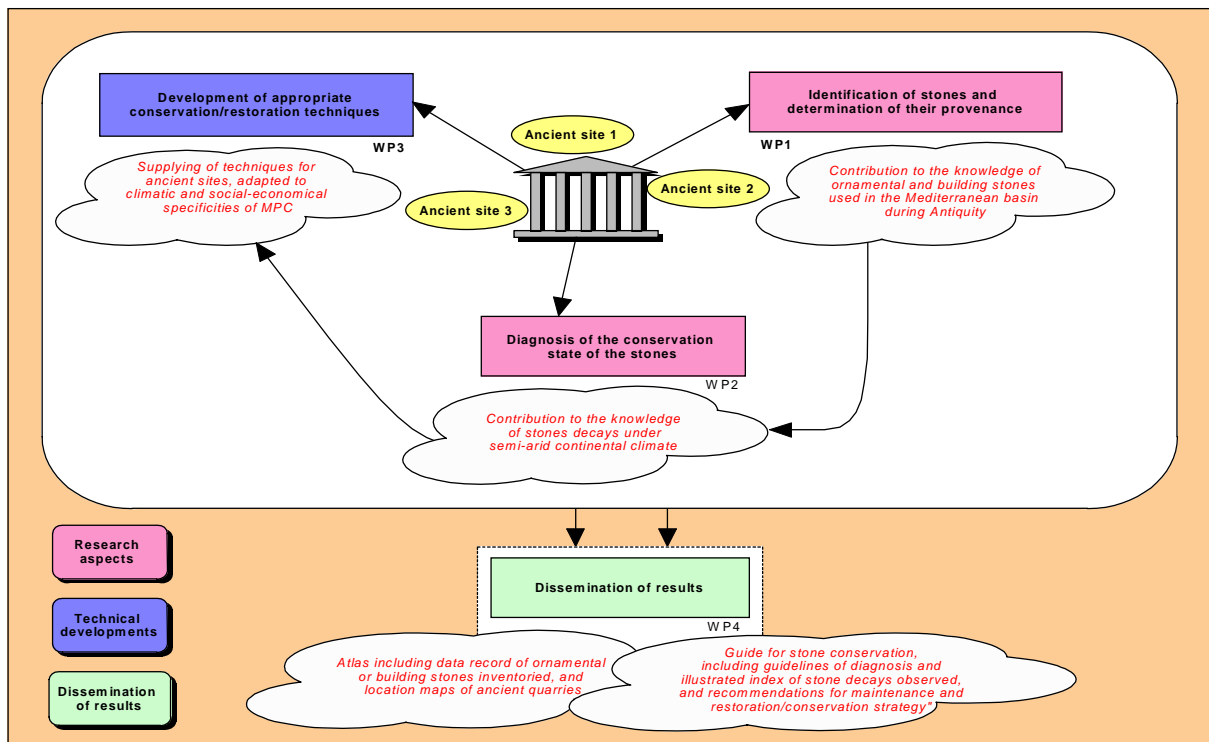
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Moreover, data management of the obtained results will include circulation of the information between the non-European Mediterranean countries, and dissemination of the obtained results to partners but also to the whole scientific and technical community through :

- guidelines of best practice for conservation of stones in arid and semi-arid areas
- organisation of two international workshops (work package WP 4).



Visualisation of integrated and strengthened EU expertise in MEDISTONE, ready to apply to twinned non-European partners



Identification of stones and their determination of their provenance (WP1) :



Theater, Djemila, Algeria

Two centuries have gone by since the publication of the treatise « *Delle pietre antiche* » by a famous Roman lawyer. This document is a major source of information relative to marble and stone used in antique constructions and in 1971 was supplemented by the publication of « *Marmora Romana* », the first modern period bibliographical reference on the subject. The author introduced his study of antique marble based on scientific analysis of the Greek and Latin literary sources, coupled with visits of numerous quarries and antique monuments.

However, these works after publication, have on occasions been poorly applied, either through the neglect of technical aspects or by the omission of new scientific contributions. Rough estimates, and at times inaccuracies, which could have been picked up through simple geological examination of the sites and appropriate laboratory testing, have been perpetuated through to the present-day. At the present time, the region of origin of numerous decorative stones used in constructions dating from antiquity, both in the west and the orient (and often reused in the Middle Ages) remains poorly defined or even unknown.

The MEDISTONE project proposes **identifying stones used at the three selected sites and determining their origins** in terms of geographic areas and, if possible, the former quarry sites.

After a preliminary phase of information gathering on topography and architecture, every site will be subject to an inventory and sampled in order to acquire a representative collection of the principal stones. Mineralogical analyses, petrography, geochemistry, and of physical testing, will be undertaken and should enable a base to be drawn up for identification of every stone type.

The application of a specific research methodology (documentary study and field investigations) will enable potential zones of origin to be delimited. These zones will in turn be subject to a programme of sampling. Every sample will be either totally or partially subject to the analysis procedures described above, be it a decorative stone or a construction stone or of a building material of local origin or of a building material of imported origin. The comparison of analysis results between samples from monuments or quarries, and their confrontation in the specialised data-bases established in Europe, should enable absolute confirmation of area of origin and even the ancient quarry location of stones used at the selected antique sites.

Diagnosis of the conservation state of the stones (WP2) :

The MEDISTONE project proposes establishing **diagnosis of the state of conservation** of the decorative stones and of the constructions at the sites. Whilst the causes and the mechanisms of the deterioration to stone are relatively well known for temperate European climates, the semi-arid continental climate of the selected sites, characterised by strong thermal amplitudes, high evaporation and strong wind action, together bring about specific weathering and alteration requiring more thorough investigations, notably concerning the following points :

- Aeolian action.
- Roles of thermal and humidity variations on dilation and fracturing (thermoclasticity, materials fatigue).
- Role of salt crystallisation, the origin and the progress of salts.
- Inventory and part of the biologic and microbiologic surface cover in these changes.



Volubilis, Morocco

- Impact of anthropic actions (water pollution, gaseous and particulate atmospheric pollution), agricultural and industrial practices and of tourist activity.
- Contribution of products and techniques used in former restoration programmes (cleaning, repair, filling and grouting and other work executed during research and excavation and then within the framework of local traditional maintenance practice).

The main weathering forms affecting the stone at each site will be described and indexed. This descriptive on-site inventory will be coupled with *in situ* measurements. To reinforce the conservation state diagnosis and to identify main internal and external factors of the stones alteration, specific standard in-laboratory measurements on decayed stones samples will be undertaken.

Whilst the various cases of alteration that may affect stone, are well documented, this is not always the case for their mechanisms. In particular, it is not always easy to understand the causes leading to the appearance of fractures, fissuring, cracking or microfissuring, which prepare the way for further degradation such as granular disintegration, and to be able to rank those factors which are responsible.

Thus, in an arid or semi-arid milieu, salt crystallisation, temperature variations, humidity, physical properties of the stone, i.e., porosity, permeability, compressive strength, thermal dilation etc., or a combination of these factors, are evoked in order to explain the degradation of the stone in the edifice, this notably for sandstones.

The diagnosis of a stone's conservation state thus depends, in addition to its description and measurement on site, on an analysis of the different types of alteration affecting the stones, and thus upon a qualitative petrographic analysis and, insofar as possible, a quantitative analysis at a small scale of these complex alterations

Those means to be activated are thus observation techniques and analyses able to give results during the study of representatives zones of the alteration types, with extension below 100 μm^2 and possibly less than a few μm^2 .

Bibliographic research on the archaeology of the remains and the work done at each site will, through archaeological dating, enable knowledge to be established concerning the major tendencies in the environmental evolution of the sites since they were founded to the present day.

Thus, the Maghreb (Mediterranean Northwest Africa) with a humid climate at the beginning of the Holocene, during Roman times was still considered as the wheat granary for that civilisation. This climate has since evolved modifying to a semiarid to arid climate. The principal forms of in-the-edifice stone degradation in arid to semiarid climate are generally disintegration and flaking associated with saline crystallisations. Burial, which over time, leads to the formation of a surface patina on the stones, also has non-negligible consequences on the state of buried material.

The variations in environmental conditions to which the stones have been subjected, has thus led to a succession of alterations.

It is very important to bring to light these alteration phases because they are responsible for the alteration features currently visible. Indeed, the deciphering of this succession will guide the different steps taken by the restorers in their choice of conservation and restoration measures to be taken.

Finally, historical research on restoration and maintenance methods used, in terms of both products and techniques, during the 19th and 20th centuries, also need to be undertaken. Techniques have undergone major changes, particularly at the end of the 20th century, changes with regard to methods used, products employed and also in respect of the codes of practice retained. Thus, certain materials used, such as Portland cement in reassemblage, have been banished because they constitute additional degradation factors.

Development of appropriate conservation / restoration techniques (WP3) :

The MEDISTONE project proposes to **provide answers to the main problems regarding stone conservation / restoration** that are liable to be met at the three selected sites. It involves developing techniques for reassembling fractured and fissured stones. This phase will be based on European know-how, and will take into account the climatic and environmental specificity (thermal amplitude related the semi-arid continental climate at the Mediterranean located sites), as well as the social-economic context in each Mediterranean partner country. Indeed, technical solutions tried in Europe in temperate climates may be less durable or even completely ineffective and will in every case, need to be adapted and validated.

The fracturing of stone, even prior to the problem of cleaning, constitutes a major obstacle in the overall vision of a monument, and the valorisation of a heritage monument, constructed in stone. It necessarily involves, as a first step, the reassembling of these elements guided by the desire to best restore the original aspect. Virtually never treated in national valorisation projects of heritage sites, this problem involves both a scientific interest aspect, integrating completed restoration projects corresponding to the spirit of the Venice Charter (1964), and “training and technological transfer” by developing *in situ* solutions which are innovative and adapted to the characteristics of Mediterranean partner countries.

In the case of the three selected archaeological sites, the fragmented pieces of stone are generally dispersed on the ground. Other stone fragments may be missing in such a way that the remaining fragments render comprehension of the site more difficult with the risk of letting the visitor imagine erroneous historical, architectural and archaeological scenarios.

Fracturing of the stone may be linked either to human intervention i.e., voluntary or accidental operations involving displacing the blocks or objects during excavation of the site, or simply uncovering causing decompression during excavation. The latter of these processes corresponds to the rupture of an unstable equilibrium between the stone and its environment and in particular, with the material in which it is buried and with which it has coexisted for several centuries (earth, rubble etc.) The deterioration observed is for the most part as fracture or fissuring but also peeling phenomena related to crystallisation of natural salts contained in the encasing earth.

Techniques currently used in Europe make use of either mineral-based sealants which show a good degree of chemical compatibility with the stone (ultrafine hydraulic paste), or, more generally, organic compounds developed from polymer chemistry such as acrylic resins, polyurethanes or epoxies. These organic products show undeniable advantages related to their intrinsic qualities such as adhesive properties and mechanical resistance along with their ease of use related to rheological and hardening properties. The applicability and the transposition of these solutions, already proven in Europe, need to be tested in the contrasted climatic conditions of MPC, notably with regard to temperature variations which have an influence on the setting rates of the material, and ultimately on their efficiency. In parallel, it is considered important to examine and contrast specific formulations which favour the use of cheaper local products like lime, that unlike polymers, are readily available in the market places of MPCs.

The development of techniques for reassembling fractured and fissured stones will be based on a phase of specific laboratory testing, to define the limits of use and the optimal techniques and conditions for undertaking this. In order to better approach the real climatic solicitations of the sites the behaviour of a variety of different stone/binder assemblages will be laboratory tested for temperature and humidity gradients exceeding those at the sites, in order to determine the theoretical performances and the degree of risks linked to their usage at each site. The best performing compounds will be selected and their practical application conditions optimised for each site. In situ applications will be monitored at reference pre-selected test zones. This phase will provide the basis for technical protocols to reassemble fractured and fissured stones, adapted to each site.

Dissemination of results (WP4) : The scientific and technical results issuing from the MEDISTONE project will be compiled into three synthetic volumes per site, produced together by the partners involved :

- An Atlas including data record of each ornamental or building stones inventoried in the site, including Location maps of ancient quarries with explanatory notes (= results from WP1)
- A Guide for stone conservation, including guidelines for diagnosis and the illustrated index of stone decays observed on the site, and recommendations for maintenance and restoration/conservation strategy (= results from WP2)
- Technical protocols for reassembling fractured and fissured stones adapted to the site, and long-term monitoring fiches of the *in-situ* test zone (= results from WP3)

Dissemination of these results obtained during the project, and the promotion of its methodological aspects is the subject of WP4 and will be done by the means of :

- two workshops (W1 and W2) :
At the end of the second year of the project a first workshop (W1) will be organised on the theme "Preservation of ancient Mediterranean sites in terms of their ornamental and building stone: 1. Identification and origin determination of stones". This manifestation will begin with a conference mediated by an international expert and will be followed up with a succession of presentations by the various partners, each illustrating the theme being treated. At this meeting each

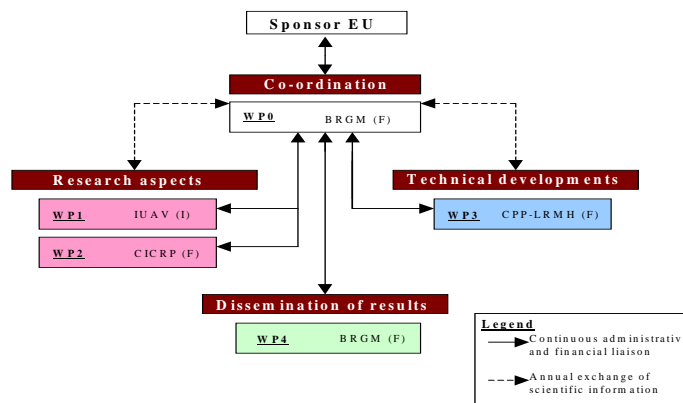
participant will be given an Atlas both as a paper document and as a CD-ROM comprising a data record of each ornamental or building stones inventoried at the three sites, and location maps of ancient quarries with explanatory notes” (deliverables D1 and D3).

At the end of the project a second workshop (W2) will be held on the theme "Preservation of ancient Mediterranean sites in terms of their ornamental and building stone : 2. Diagnosis and conservation techniques". This manifestation will be organised along the same lines as the first workshop. And during which each participants will receive an example of “Guide for stone conservation, including guidelines of diagnosis and illustrated index of stone decays observed on the three sites, and recommendations for maintenance and restoration/conservation strategy” both in printed and CD-ROM format (deliverables D4). Lasting 2 days, the two workshops will take place in two different MPC partner countries. They will be announced through a circular (notably supplying a presentation of the MEDISTONE project along with practical information on how to acquire the deliverables from the project) sent to the scientific community working in heritage archaeometric building and monument preservation. The workshops will be open to the partner research teams of the project, to the whole scientific community and to representatives of the European Commission.

- Usual channels of dissemination :
Each participant will also contribute to the valorisation of the results of the MEDISTONE project by their respective national networks, Publications in national and international scientific and applied journals, communications at national and international congresses, Contribution to associative, sectorial or national web sites dealing with archaeometry, stone conservation, cultural heritage.
- Training of doctorate students, employed by each MPC university or research institution (i.e participants no. 9, 11 and 14 ; one student by Mediterranean Country) in the fulfilment of their contributions to the project, during the 3 years of the project. On one hand this will enable a transfer of know-how from the EU scientists to a new generation of MPC scientists and on the other hand, enhance the transfer and diffusion of data and knowledge in this direction. These students will be supervised and guided by both the EU scientists and those scientist from their respective countries.

Project management (WP0) :

The overall management of the MEDISTONE project, for which the proposed structure is shown in figure below, will include several points.



Work under progress

Inception Meeting



Working session at CICRP (Marseille)

The project kick off meeting took place on the 23rd and 24th March 2006 in Marseille (France). All the partners were present except representatives from the two Algerian organisations (University of Boumerdès: absence of Dr. Hamiane because of problems obtaining a visa; Algerian Ministry of Culture: awaiting detail on the structure of the project's integration within the Ministry as a replacement of the National Agency for Archaeology, and Protection of Historical Monument Sites whose missions have been changed). The partners were received at the premises of the CICRP (Centre Interrégional de Conservation et de Restauration du Patrimoine), by Dr. BROMBLET and Dr. VALLET.

The morning of the 23rd April was devoted to a review and a presentation of the project as a whole by the coordinator Dr. DESSANDIER, who developed the following principal themes: objectives, participants, management, work plan, budget. He indicated that the contractual starting date with the European Commission for MEDISTONE is the 1st January 2006 and that the 3 month effective delay in starting was linked to the acquisition of the « Form A documents – Accession to the contract » from certain Mediterranean partners. Also indicated was the crediting for the first pre-financing payment by BRGM, in its function as organisation coordinator, which for each partner would take place in April, for those having duly signed the « Consortium Agreement ». Partners having still not signed were asked to make haste in obtaining signature of this document in order to receive the pre-financing as soon as possible.

The afternoon of the 23 March was mainly devoted to the **technical launch of the project with the practical aspects of the first missions** together of the partners to the 3 archaeological sites of the study:

- Morocco / Volubilis : the first mission is scheduled for the 17th May 2006 for a period of one to two weeks according to the partner involved. The detailed programme of this initial reconnaissance mission will be drawn up by Prof. KAMEL of the Moulay Ismail University, Meknès with the back-up of the Moroccan Heritage Council (Direction du Patrimoine) and communicated to the partners.
- Egypt / Alexandria Light House: a similar reconnaissance mission was provisionally scheduled for the period 1st to 7th July 2006, the details of which will be communicated later to those partners involved, by Prof. SHOEIB, representative of the Egyptian Supreme Council of Antiquities.
- Algeria / Djemila Site (formerly Cuicul): because of the absence at the Kick Off meeting of our Algerian partners, it was decided that Dr. DESSANDIER, project coordinator would go to Algeria in April in order to make advanced contacts for a preparatory visit of the site with the objective of a first site study mission of about 2 weeks in October 2006.



“Jardin des Vestiges” (Marseille) visit

The morning of the 24th March was spent visiting the Vestiges Garden (Jardin des Vestiges) guided by Mr François Hervé, lecturer at the Marseille History Museum. This garden was established in 1975 in order to display *in situ* antique vestiges of the city brought to light during construction work of the Centre-Bourse quarter. Visible are vestiges of the northern rampart and



road paving slabs from the Greek period (IVth century BC) and parts of quays from the Roman period (IInd - Ist century BC) as well as a reservoir in sculpted stone for sweet water storage. Different qualities of stone from near and far were used and show various degrees of degradation. Visiting this archaeological site thus prompted discussions on certain problems common to the MEDISTONE project.

Report on the coordinators visit to Algeria from 21st to 24 April 2006

As discussed during the Kick Off meeting in Marseille, coordinator Dr. DESSANDIER visited Algeria from the 21st to 24th April in order to establish advanced contacts with the Algerian partners concerning three points:

- Contractual discussions with the Ministry of Culture, the rector of Boumerdès University (a point not detailed in the present report).
- Preparatory visit to the Djemila site
- Inventory of scientific apparatus in the Department of Material Engineering in Boumerdès University.

The following persons were met:

- Dr. HAMIANE, Lecturer in the Department of Material Engineering in Boumerdès University (partner No. 9) / Technical manager for the MEDISTONE project at Boumerdès University (partner n°9) ; organiser of the visit programme in Algeria.
- Ms Prof. KESRI, Rector of Boumerdès University/ Administrative manager of the MEDISTONE project for Boumerdès University.
- Dr. SAIDI, Head of Department of Material Engineering in Boumerdès University.
- Ms NAIMA, Doctorate student on the MEDISTONE project within the Department of Material Engineering in Boumerdès University.
- Mr. RIACHE, Director of the National Archaeology Museum of Sétif / Technical Manager for the MEDISTONE project for the Algerian Ministry of Culture (partner No. 8).
- Ms ZADEM, Director of the Legal Protection of Cultural Heritage and Valorisation of Cultural Heritage / Administrative manager for the MEDISTONE project for the Algerian Ministry of Culture (partner No.8) / Algiers.
- Mr. BOUKHENOUF, Engineer at the National Agency for Archaeology and the Protection of Historical Sites and Monuments, Algiers.
- Mr. KEBBOUR, Head of the Archaeological Circumscription for Sétif-BBA-M'Sila.
- Mr. LAMRI, Archaeological – Conservator for the Archaeological Circumscription for Sétif-BBA-M'Sila; involved in the Djemila site.



Colonne en albâtre dans le Musée de Djemil

The visit to the antique Djemila site (formerly Cuicul) took place under the guidance of Mr. LAMRI, Archaeologist – Conservator of the Archaeological Circumscription for Sétif-BBA-M'Sila, involved in work at the site since 1998. The site exposes a current area of 42 hectares that has been subject to open air archaeological investigations to which can be added a covered museum that assembles numerous mosaics originating from the site, along with.



Collection de marbres



Extrait de la maquette de 1937



Vue du site antique



Construction en « Opus Africanum »

diverse archaeological elements including a collection comprising about 20 samples of marble. In addition, there is an excellent-quality scale model of the site dating back to 1937, which provides a site overview and is appreciable for measuring the dimensions of the site and for position locating. The site visit also enabled verification of the provenance of a certain number of decorative or architectural elements made of coloured or white marble. According to Mr. LAMRI, some of these came from the TLEMCEN region and others from the SKIKDA region. The construction stone used (construction in « opus africanum ») is a grey to beige ochre marble limestone veined with calcite. The original antique quarry site is located near to the site in a valley according to Mr. LAMRI. This first rapid examination of the site enabled note to be made of the presence of numerous fractured stone pieces. Other forms of weathering observed are limited for the most part to the presence of lichen. The high level of hardness of the stone employed in construction would seem to have preserved them from « desquamation / skin peeling » type and « sand disaggregating / alveolisation » weathering.

The visit to the laboratories of the Department of Material Engineering in Boumerdès University, was conducted by Dr. SAIDI, head of Department. The main objective was to inventory available scientific apparatus likely to be used in the framework of the MEDISTONE project. Department of Material Engineering disposes of so-called education laboratories as well as a research laboratory which is particularly well equipped and dedicated mainly to the characterisation and the study of concrete and binder behaviour. The main apparatus inventoried are given below:

- Rheometer (-150°C à 600°C)
- Viscosimeter
- Zetameter
- Cathodic pulverisation reactor
- Spectrophotometer (UV to IR)
- Atomic absorption
- XR Fluorescence
- X ray diffractometer
- Mechanical press 3000 KN
- Mechanical press 250 KN coupled with a furnace (0°C à 900°C)
- Mechanical press 90 KN
- Durometer and microdurometer
- Press with structure for flexure measurement to 100 KN
- Laser grain size analyzer
- Sorptometer (mesuring BET)
- ATG-ATD-DSC
- Thermal dilatometer (up to 1500°C)

Much of this apparatus, particularly mechanical could be put to use in the framework of the MEDISTONE project, notably for Work Packages WP1 (tasks relative to the characterisation of the stone) and WP3 (tasks relatives to the study of the behaviour of adhered stone product assemblages).

Various Informations

Next project meeting

January 2007 in Venice (Italy) at the IUAV Università di Venezia – First MEDISTONE Project Progress Meeting with participation of all partners.

Next issue of Newsletter

N°2 (august 2006).

Next Dissemination of MEDISTONE results

Presentation of a POSTER and an EXTEND ABSTRACT of MEDISTONE at the :

- 7th European Commission Conference “SAUVEUR” : SAFEGUARD CULTURAL HERITAGE Understanding & Viability for the Enlarged Europe – Prague, Czech Republic – 31st May – 3rd June 2006.
- 8th International Conference of ASMOSIA (Association for the Study of Marble and Other Stones Used In Antiquity) – Aix-en-Provence, France – 12-18 June 2006.

