



# MEDISTONE

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

## Newsletter n°6 January 2008

### Editorial

Welcome to the sixth 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 second year of the project (from January to December 2007).

It also includes a focus on the two Moroccan partners involved in MEDISTONE, i.e. the Cultural Heritage Direction (Culture Ministry) and the University of Meknès.

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 2<sup>nd</sup> year of the project

During the second year of the project (from January to December 2007), the major achievements of the project may be highlighted as follow.

### WP1: Identification of stones and determination of their provenance

#### VOLUBILIS SITE (MOROCCO)

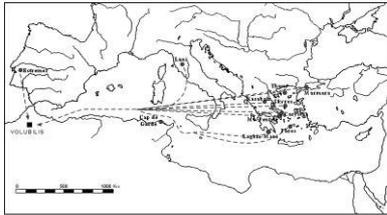


Figure 1 - Provenance of the imported white and coloured marbles found at Volubilis.

Concerning **Volubilis**, the second year of the project began with the continuation of the research of ancient quarries of ornamental and building stones. According to the bibliographic references, the supposed ancient quarries of Aïn Schkor area were located, described and sampled for in-laboratory analysis. It is an extensive area of very numerous small to medium size quarries. Many traces of ancient exploitation are visible. Three marble quarries located in Central Morocco (near Khénifra City - about 120 km in the south of Volubilis) that have potentially supplied decorative material for Volubilis were visited, described and sampled : Hreni-Ifrou quarries, supplying a whitish marble striped with greyish, micro-fractured, Bou-Acila quarries, supplying a whitish marble striped with maroon, Tiskram quarries, supplying a whitish marble striped with greyish. From each of the previous quarries, about thirty samples were collected and submitted to a complete in-laboratory characterisation with the objective to be compared to the Volubilis samples collected previously. About the ornamental stones of Volubilis, the identification of the white and coloured imported marbles and stones was achieved (Fig. 1). All of the found coloured lithotypes resulted imported from the Greece (*cipollino verde*, *verde antico*, *rosso antico*, *breccia di settebasi*) with the exception of the so-called "Portuguese pink", a pale pink marble exploited by the Romans near Vilaviçosa in the ancient *Lusitania*. As regards the white marbles employed in the statuary, the petrographic study in thin section and the  $\delta^{13}\text{C}$  e  $\delta^{18}\text{O}$  isotopic data emphasize the frequent use of the lunense and pentelic marbles. The white marbles used for *crustae* and architectural elements together are the dolomitic variety of the Thasian marble, the Parian marble from Lakkoi, the Proconnesian marble from the island of Marmara, an unknown marble most probably of local origin and a variety of the so-called "*greco scritto*" whose provenance still remains indefinite.

#### ALEXANDRIA LIGHTHOUSE (EGYPT)

Concerning the **Alexandria Lighthouse**, the second year of the project began with the continuation of the in-laboratory analyses on the samples collected during the first year of the project (about seventy). According to bibliographic data, most of the stones corresponding to coarse pink granite and dark granodiorite are supposed coming from quarries located around Aswan City and a geological survey was carried out in this area. About thirty samples were collected and submitted to an in-laboratory characterisation. The quarries of the coarse pink granite were mainly located at the eastern bank of the Nile Valley, in an area between Aswan City and El Shellal district to the south. The granodiorite quarries were mainly located in the south of Aswan city around Gebel Ibrahim Pasha and Gebel Togok. On the basis of the in-laboratory results, the stone samples from the Alexandria Lighthouse and those from quarries were compared and classified into types.

The works focused on the main types of stone observed in the Alexandria Lighthouse, i.e. the granites and granodiorites. Parallel to Granitoïd study, the search of ancient quarries of quartzite and silicified sandstones, kinds of stones used in several monument object related to the lighthouse began with the study and sampling of two areas, Gebel El Ahmar (east of Cairo) and El Silsila, El Gaafra and wadi Abu Subeira (north of Aswan).

### DJEMILA SITE (ALGERIA)



Figure 2: The most representative and widely found varieties of "Greco scritto" from the Cap de Garde quarry.

Concerning **Djemila**, some of the analyses of the samples collected on the ancient site and outcrops and quarries during the first mission of the end of 2006 are still in progress. About the ornamental stones, the imported coloured marbles and stones were recognized: *serpentino*, *cipollino verde*, *rosso antico*, *breccia di settebasi*, *verde antico*, from Greece; *giallo antico*, *alabastro a pecorella*, *greco scritto*, from North Africa; *granite misio* and *africano* from Asia Minor are the marbles identified both in public buildings and private houses. As regards the study of the grey marbles looking as the so-called "greco scritto" (Fig. 2), a complete mineralogical-petrographic and geochemical characterization of the marble was conducted. The data bank relating to the quarried material, created here for the first time, was used to verify its origin. The results of this archaeometric study support the hypothesis that the "greco scritto" used in the Roman Mediterranean originated from different sites, and suggest the existence of a larger number of North African quarries, also in the vicinity of Annaba.

### **WP2: Diagnosis of the conservation state of the stones**



Figure 3: Rectified picture of the front face of the red sphinx from the Opened Air Museum of Alexandria

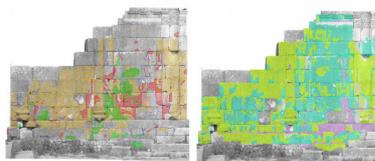


Figure 4: Mapping on the West wall of Volubilis Basilica (Volubilis Morocco).

The major achievements during the second year of the project concerned mainly the in field activities. Concerning both **Egypt and Morocco**, Partners n°3 / CICRP, n°7 / PONS ASINI, n°10 / Conservation of Volubilis, n°11 / University of Meknès and n°14 / Suprem Council of Antiquities achieved the investigations on alteration patterns. Particularly, were observed described and sampled granite quarries in Aswan (Egypt) in order to characterize the first steps of the alteration of this stone). The catalogue of the different damage phenomena was completed for Alexandria Lighthouse. Partner n°7 / PONS ASINI also produced for the five chosen masterpieces (one sphinx in granite, one in quartzite, two fragments of a third one which is in granodiorite, a colossus in granite in two parts and a monumental jamb in granite) rectified photos of the studied objects (Fig. 3), mapping of the alteration patterns and the corresponding digital documentation. Concerning Volubilis (Morocco), Partners n°3 / CICRP, n°10 / Conservation of Volubilis and n°11 / University of Meknès performed ultrasonic velocities measurements on the different petrographic types of stones and the selected stones for reassembling experiments (for WP3). It was observed an evolution of some alteration patterns, especially on the Basilica reference wall since the measurement of May 2006 (Fig. 4).

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

After field missions in the studied sites, the efforts were centred during the second period of the project on the techniques required for reassembling fractured stones and the compatibility criterions between stone types and products.



Figure 5: Equipment used for dilation acquisition data = Climatic chamber (T°C cycling) and Inductive displacement sensors (accuracy = 0.35 µm)

About the selection of suitable products used for sealing, binding and injection resistant at average temperatures of  $>60^{\circ}\text{C}$ , the time dedicated to this task was used to achieve the selection of the potentially compatible reassembling products to be lab-tested including the realisation of specimens based on traditional home-made mix-designs. For Volubilis and Djemila archaeological sites, as far as limestones are involved two ready to-use products PLM and LEDAN were selected. For Volubilis, a traditional reassembling mortar was made based on local materials. For Djemila, no traditional mortar was made for security reasons limiting the moves in the surrounding area of the site. Several tests were made by Partner n°5 / LITHOS in order to optimise the mix-design of the traditional mortar: including: fluidity test, water retention capacity, contact angle test and cracking test. For the light-house with a sealing problematic, 3 epoxy resin products (AW103, Hiliti RE500, ArgePox) were selected and a research plan of the locally used material was proposed to the Egyptian PhD student (Partner n°14) during his training stay in CPP/LRMH laboratory. For Volubilis and Djemila, the representative fractured stones were sampled in site as well as their parent rock in the supposed original quarries during the first year of the project. For the light-house, to achieve the sampling step a second fieldwork in Egypt was necessary in order to have samples large enough for the laboratory reassembling experiments. This mission was carried out in March 2007 in Aswan area known as the privileged source of plutonic rocks (granite and granodiorite) used for sculptures. The field investigations drove the sampling according to the goal of the WP3. 3 blocks of coarse-grained granite were collected (one fresh granite from a quarry North of Aswan, 2 samples slightly altered from an other quarry along NE-SW fault) ; 2 large samples of granodiorite were also collected from Ibrahim Bacha quarry (one phenocrysts-rich and the other phenocrysts-poor). Granodiorite samples are extremely dense and don't show any alteration sign.

Concerning the in-laboratory study of the thermal-hydric behaviour of assembling test stones/products, after the achievement of the sampling step of the 3 sites, the target was focused during this second year on the identification of the compatible product with each stone-type through a full characterisation / understanding of stone composition/mineralogy/thermal & mechanical behaviour. Several laboratory data acquisitions were realised by CPP/LRMH:

- Dilation behaviour: calibration of the purchased dilation equipment (Fig. 5) was achieved according to stone types and then tests protocols were established taking into account mainly the occurrence of expansive minerals as clays. Dilation behaviour under temperature cycling, of the samples coming from Volubilis, Djemila and Light-House was achieved as well as the behaviour of two ready-to-use products. Dilation behaviour under humidity cycling for the same samples is in progress.

To fully understand the dilation of stones and to reach the stone compatibility with reassembling products, acquisition of additional data have been undertaken:

- Clays separations: the nature of expansive minerals and their proportion within a stone can change radically its thermal dilation indeed in Volubilis a long-time needed to reach dilation equilibrium of some samples, required mineral separation in order to identify the expansive phases involved. Clay minerals as potential expansive phases have been separated through a normalised procedure.

- X-ray diffraction: the X-ray diffraction is used for mineralogical identification of studied whole samples, as well as for the characterisation of the expansive phases when mineral separation was needed / achieved. It was the case for example for the soft yellowish limestone coming from Volubilis.

- Additional methods: to fully understand the thermal dilation behaviour of stones other physical characteristics were needed. The pore-size distribution (using mercury porosimeter) of all samples studied were achieved for Volubilis samples and ongoing for Djemila and light-House samples. Shortly, temperature transfer after a controlled heating of the stone and the reassembling product will be studied.

## Focus on partners

### Partner n°10 - DPC (Morocco)

#### **DPC – Direction du Patrimoine Culturel, Service de Conservation du site de Volubilis (Morocco):**

DPC is a Moroccan Public Institution for the Conservation and the Restoration of Cultural Heritage. This scientific and technical institution is overseen by the Ministry of Culture with, as its main mission, to inventory the archaeological, historical, artistic and cultural heritage of the country and to study, protect and promote these heritages.

The Volubilis site conservation service depending of DPC, is constitute by 32 people : 8 for administrative management: Director (archaeologist), Deputy Director (archaeologist) and 6 secretaries, and 20 for site management (1 technician in restoration and consolidation, 1 draftsman, 14 workmen (excavations, restoration), 4 security personnel / receptionist and marketing (tourism)). The service has excavation equipment and surveying equipment.

### Partner n°11 - MIUM (Morocco)

#### **MIUM – Moulay Ismail University of Meknès, Surface and Environmental Geology Unit (Morocco):**

The Moulay Ismail University of Meknès was created in 1982. Given the rich historic background of the town, research at the University of Meknès has a strong and pervasive historical and Cultural Heritage preservation theme. Its Surface and Environmental Geology Unit:

- Research Team: Training and Research Unit called " Surface and Environmental Geology Unit" (UFR) is made up of 10 researchers from varied disciplines and 8 post graduate PhD students.

- Objectives and aims: To study the dynamics of surface formations and undertake assessments on transfers; to study environmental impacts and the filling and eutrophication of closed systems.

- Key-words: Soil, crust, slip, erosion, deterioration, clays, aerosols, silting, eutrophication, sediment, suspended matter, pollution, geochemistry, flow of matters, lakes, retained heavy stopping, environment, nutriments, metals, speciation, adsorption.

- Equipments: Thin section laboratory, centrifuge machine, polarising microscope, optical microscope.

## Various Informations

### Next planned meeting

- WP1-WP2: Complementary field works on Djemila site and corresponding ancient quarries at the beginning of March 2008.
- Progress meeting for whole partners the 22 March 2008 in Meknès / Morocco (after the first MEDISTONE Workshop).

### Next training for doctorate students

- Training of the Egyptian doctorate student Mohammed El Rhoddani (partner n°14 / Suprem Council of Antiquities) on diagnosis of the stone conservation state (Mai or June 2008 – Place: CICRP Marseille, France).

### Next issue of Newsletter

N°7 (May 2008).

### Dissemination of results

- First MEDISTONE Workshop on the theme "Preservation of ancient Mediterranean sites in terms of their ornamental and building stone: 1. Identification and origin determination of stones" planned the 20-21 March 2008 in Meknès / Morocco
- Presentations of COMMUNICATIONS (dealing with WP1, WP2 and WP3 results) planned at the 11<sup>th</sup> International Congress on Deterioration and Conservation of Stone – Torun, Poland – September 15-20, 2008.
- Article (WP1) submitted to *Archaeometry*, Blackwell, Oxford - Title: Minero-petrographic and geochemical characterisation of "greco scritto" marble from *Cap de Garde* near *Hippo Regius* (Annaba, Algeria).
- Article (WP1) submitted to *Journal of Cultural Heritage* (a multidisciplinary Journal of Sciences and Technology for Conservation and Awareness), Elsevier - Title: Volubilis (Meknes, Morocco): archaeometric study of the white and coloured marbles imported in the Roman age.



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