

International Research Staff Exchange Scheme (IRSES)

# MEMOQUAT

Man and Environments in Morocco during Quaternary



**PEOPLE MARIE CURIE ACTIONS**  
**International Research Staff Exchange Scheme**  
**Call: FP7-PEOPLE-IRSES-2008**  
**MEMOQUAT (Man and Environments in Morocco during**  
**Quaternary)**

## WORKING PACKAGE 1: EXCAVATIONS AND SURVEYS

### PLAN:

- 1) Excavations and surveys in Atlantic Coast, Rabat-Témara region
- 2) Surveys and researches in Tafilalt, Draa Valley and Ouazzane regions
- 3) Pleistocene Palaeo-sea-levels and near-shore dunes of the Agadir coastal area, Morocco: IRSL and U/Th Datings. Geological prospections and chronological studies
- 4) Climate, human occupation and travertine deposits in Morocco

## 1) EXCAVATIONS AND SURVEYS IN ATLANTIC COAST, RABAT-TÉMARA REGION

### 1.1) General framework and human territories

Roland NESPOULET and Mohamed Abdeljalil EL HAJRAOUI

#### Introduction

The Rabat-Témara region is a key area for the Moroccan Prehistory (figure 1). It has been known for over 70 years and has delivered numerous archaeological artifacts, sometimes in association with human remains. Despite the archaeological richness of the region and the large number of works conducted by several generations of researchers, many questions remained unanswered.

The aim was 1) to clarify the dating of the Palaeolithic phase occupations, 2) to better understand the geological phenomena of caves formation and filling, and 3) to establish the regional paleoenvironmental framework.

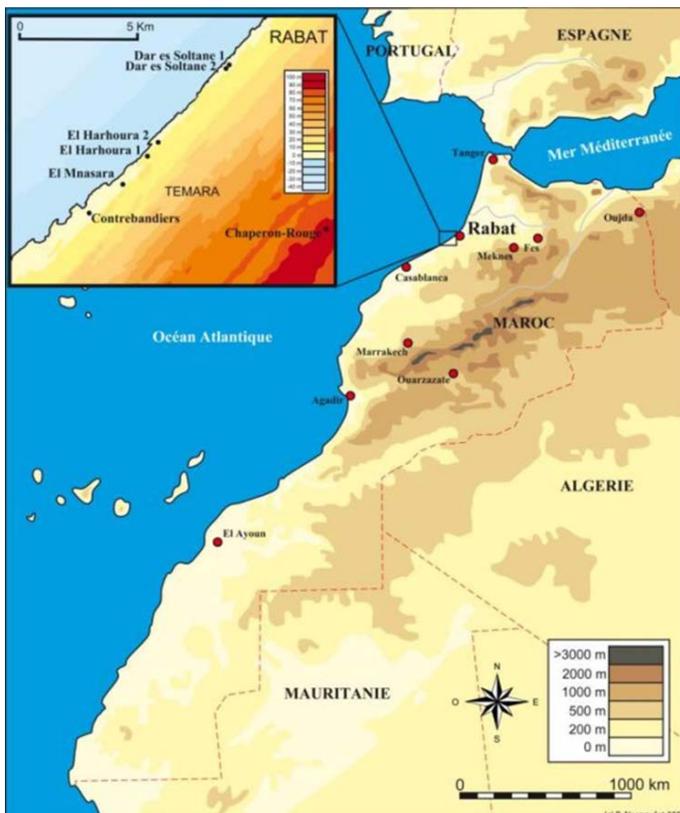


Figure 1: map of sites of Rabat-Témara sites (Excavated : El Mnasra and El Harhoura 2)

Lithic industries were described, but behaviors (knapping stones, hunting strategies and symbolic objects) of the first occupants of Rabat-Témara remained largely unknown. Given the great antiquity of human occupation of the Rabat-Témara region, more than 120 000 years to the first Aterian *Homo*

*sapiens*, these issues have taken on an international dimension with the questions, across the African continent, the origin and dispersal of anatomically modern humans.

It is from this observation that we have developed the scientific problem and the main objectives of field operations, in relation with the other actions of MEMOQUAT Program. The excavations were necessary to renew and enrich the archaeological record, in a perspective of interdisciplinary studies at high resolution. The four years have allowed us to strengthen scientific cooperation between France, Italy and Morocco in order to better coordinate all the analysis studies from the field to the laboratory. The discoveries and the results were consistent. They help to draw rich scientific results and scientific perspectives, research training and skills transfer.

### Main results

The main contributions of the Rabat-Témara region concern both men behaviors and their environment. The only known human remains of *Homo sapiens* in North Africa reportable to isotopic stage 5 are from the Rabat-Témara region. The newly discovered remains confirm this diagnosis since they are identical to those previously discovered.

Data on prehistory of this region have been updated and methodological confrontations have been made, both in the area of the excavation as analyzes. The excavations were conducted simultaneously in two sites with the same protocol (fine excavations computer-assisted systematic sieving). The analyzes were performed with the same methods: dating (OSL, ESR, 14C). Samples for ESR dating (animal teeth, sediment) have been processed and analyzed Lasmar Meknes and MNHN in Paris.

The combined ESR-U/Th method applied to fossil herbivorous teeth allows a chronostratigraphical view thanks to guide marks precisizing the palaeoenvironmental frame in which men lived during Palaeolithic period in Morocco. All the dated layers are attributed to Aterian culture.

The analyses have been performed on bovid fossil teeth unearthed from layers 8, 5 and 4a at El Haroura 2, and from layers 7, 6a and 6 at El Mnasra Caves. The results range between 92 and 44 ka for El Haroura2, and between 89 and 62ka for El Mnasra. These results confirm that Anatomically Modern Humans were present in this area at the MIS5 (table 1).

Site-Sample	Level	( $\beta$ + g) sediment + cosmic ( $\mu$ Gy/a)	Internal dose ( $\alpha+\beta$ ) enamel ( $\mu$ Gy/a)	$\beta$ dose Cement ( $\mu$ Gy/a)	Total dose ( $\mu$ Gy/a)	p enamel	p dentine	p cément	Age (ky)
EL MNASRA									
EM0601	7B	491	46	23	560	-0,66 $\pm$ 0,18	-0,62 $\pm$ 0,07	-0,7 $\pm$ 0,08	66 $\pm$ 2
EM0603	6A	481	53	30	574	-0,59 $\pm$ 0,2	-0,66 $\pm$ 0,06	-0,72 $\pm$ 0,09	67 $\pm$ 2
EM0604	6	491	21	11	523	0,03 $\pm$ 0,51	0 $\pm$ 0,14	0,14 $\pm$ 0,21	89 $\pm$ 6
EL HARHOURA 2									
EH0605	4A	420	13	9	442	11,08 $\pm$ 0,77	-0,10 $\pm$ 0,15	-0,03 $\pm$ 0,27	44 $\pm$ 3
EH0603	5	366	22	72	460	0,68 $\pm$ 1,39	0,53 $\pm$ 0,18	---	62 $\pm$ 4
EH0601	8	362	20	51	443	0,27 $\pm$ 0,67	-0,01 $\pm$ 0,22	---	92 $\pm$ 11/-9

Table 1: Annual Dose, p factors for each tissue, and ages obtained accompanied by a sigma error.

The external dose comprises the dose from sediment and that due to cosmic.

Two types of measures were carried out.

Approximately 100g of unsorted sediment were measured one month after packaging.

TL dosimeters were placed where the analyzed sediments were collected.

The stratigraphic sequences of El Mnasra and El Harhoura 2 caves (figures 2 and 3) have been reassessed and clarified. These interpretations and lithostratigraphic archéostratigraphiques rely on methodical excavations and the systematic study of the archaeological material. The exhaustive archaeological samples are thus comparable. The archaeological levels being well preserved, a taphonomic study has been conducted, particularly regarding microfauna.

The contribution of fauns and microfaunas has been completely renewed, as well as the geochronological framework, highlighting more seniority than was admitted. The correlation of main phases with Aterian occupations isotopic stages 5-3 and caves between them has been established.

Clarifications were made to our knowledge of the Neolithic: burials in caves and many paleopathological studies, accompanied by comparisons with contemporary populations (Rouazzi Skhirat necropolis).

The study of the lithic industries and the raw materials resources revealed flint on primary deposits, while it was generally thought that this material solely from pebbles collected in the wadis. The presence of tanged tools in the Middle Palaeolithic industries is not constant at all sites: they exist in El Mnasra (figure 4), but they are absent in El Harhoura 2 aterian sequence. The contemporaneity of sites with and without tanged tools shows that these artifacts are not a sufficient criterion to define Aterian versus Mousterian culture.



Figure 2: Excavations at El Mnasra Cave(photos R. Nespoulet)



Figure 3: Excavations at El Harhoura 2 Cave(photos R. Nespoulet)

#### Complexity of human occupation on the Atlantic coast of Rabat-Témara

The contribution of archaeological data caves of El Harhoura 2 and El Mnasra revealed human occupation phases brief or relatively permanent, alternating with phases of abandonment of the caves, which are expressed both in sedimentary levels archaeologically sterile or by occupations of non-human predators (carnivores).

Perennial occupations are characterized by lithic series well preserved and relatively abundant wildlife assemblages whose primary storage medium is Man, and anthropogenic structures (homes, riprap). They can be regarded as establishments 'sustainable' of human groups in the cavities with a broad range of domestic activities: cutting and shaping of the lithic and bone tools, butcher, consumption, lights and amenities of habitat.

The occupations 'short' are characterized by lithic series scarce and the absence of anthropogenic structures.

The phases of complete abandonment of the cavities are archaeologically and faunistically sterile. However microvertebrates remain can be abundant, reflecting attendance caves by specific predators (raptors, small carnivores).

It is possible to distinct chronological phases of these different modalities of occupations / abandonment of cavities. The main trend is that the "long-term" occupations are rather situated during the humid climatic phases, corresponding to marine transgressions (5e and 5c sub-stages IS). The caves were then in coastal context such as the current coastline. Conversely, phases of neglect by man, and / or phases during which the caves are benchmarks of carnivores, are instead located in the arid phases when the shoreline was located up to 40 km further west (5b and 5d sub-stages IS, IS 4). The cavities were then in a stronger continental context.

### Two scenarios of human territories

The first scenario favors the hypothesis of a “coastal corridor” in which human populations preferentially settle in coastal areas. In this case, drop phases cavities by Man (and the activities “secondary” of scavenging) correspond to a shift of habitats in the coastal strip between -120 m and 0 m above present sea level. Documentation, submerged, is currently inaccessible, but other examples indicate that this scenario is possible, such as in Gibraltar.

The second scenario assumes a more diverse range of occupations (up temporary camps to specialized facilities 'sustainable', as well as cave and outdoor). In this case, it must be noted that with few exceptions (outdoor site Red Riding Hood), no documentation is currently in the hinterland of Rabat and Témara, research misconduct and systematic surveys on field.

If the first scenario will not find a response in the field survey, the latter may be supported by several approaches and observations. The lithological data allow for example to consider the procurement of raw materials lithic territory was larger than previously thought. Some raw materials that are in fact attested in archaeological series do not exist in the Témara local environment. Similarly, the fact that the supports of the stone tools are still being finished or semi-finished form not only indicates a high mobility of human groups, but also the activities of processing and delivery system were made outside the cavities, or on deposits of raw material themselves or in specialized sites. The prospect of a systematic assessment of this potentially present information in the hinterland would therefore appear to be essential to validate or invalidate the hypothesis of a geographically broader network of specialized sites.

### Conclusion

Research conducted in the field and in the laboratory as part of the program and e MEMOQUAT scientific collaboration Franco-Moroccan has increased the resolution of geochronological analyzes, taphonomic and archaeological. One note paleoenvironmental reconstructions should be further refined, in particular by specifying the sedimentary dynamics and taphonomic history of micro and macro vertebrate assemblages.

The complexity of human occupation on the Atlantic coast of Rabat-Témara had been underestimated in previous studies. This region of Morocco is more than ever a reference region, but the stratigraphic and archaeological sequences are now more detailed and nuanced. New human behaviors, previously unknown, appear very early. The region of Témara was occupied by early anatomically modern humans from the start of stage 5, and archaeological remains they have left us evidence of their cultural modernity. This region thus participates fully to the questions of the origin and dissemination of the cultures of modern humans in Africa and outside Africa.

We have thus laid the groundwork multiple answers to the question of the place of Palaeolithic and Neolithic cultures, not only in Morocco, North Africa, but also across the African continent.



Figure 4: El Mnasra. Level 8. Aterian lithic industry. a: tanged point, b: Levallois retouched and tanged blade; c: Levallois micro-flake; d: Levallois micro-core (photos R. Nespoulet).

## 1.2) Contribution of geology in the knowledge of the changing environment of prehistoric men of Rabat-Témara

Driss CHAHID

### Introduction

The study area is located on the Atlantic coast, belongs to the northwestern coastal Meseta. It is geographically limited by the city of Kenitra northeast, by the city of Skhirat south west and the Atlantic Ocean to the west (figures 5 and 6).

This region has benefited from the attention of quaternarists and prehistorians since the 1920s, but the chronostratigraphy and geodynamics of the implementation of the quaternary formations remain unknown and many ambiguities persist.

The caves sites are located in the second cord in which is shaped cliff of the last interglacial. These sites deliver archaeological and anthropological witnesses of human groups that populated the Atlantic coast during the last glacial cycle.

Knowledge and reconstruction of landscapes frequented by prehistoric men is essential for understanding men-environment relationships on a long time, more than 120 000 years BP.

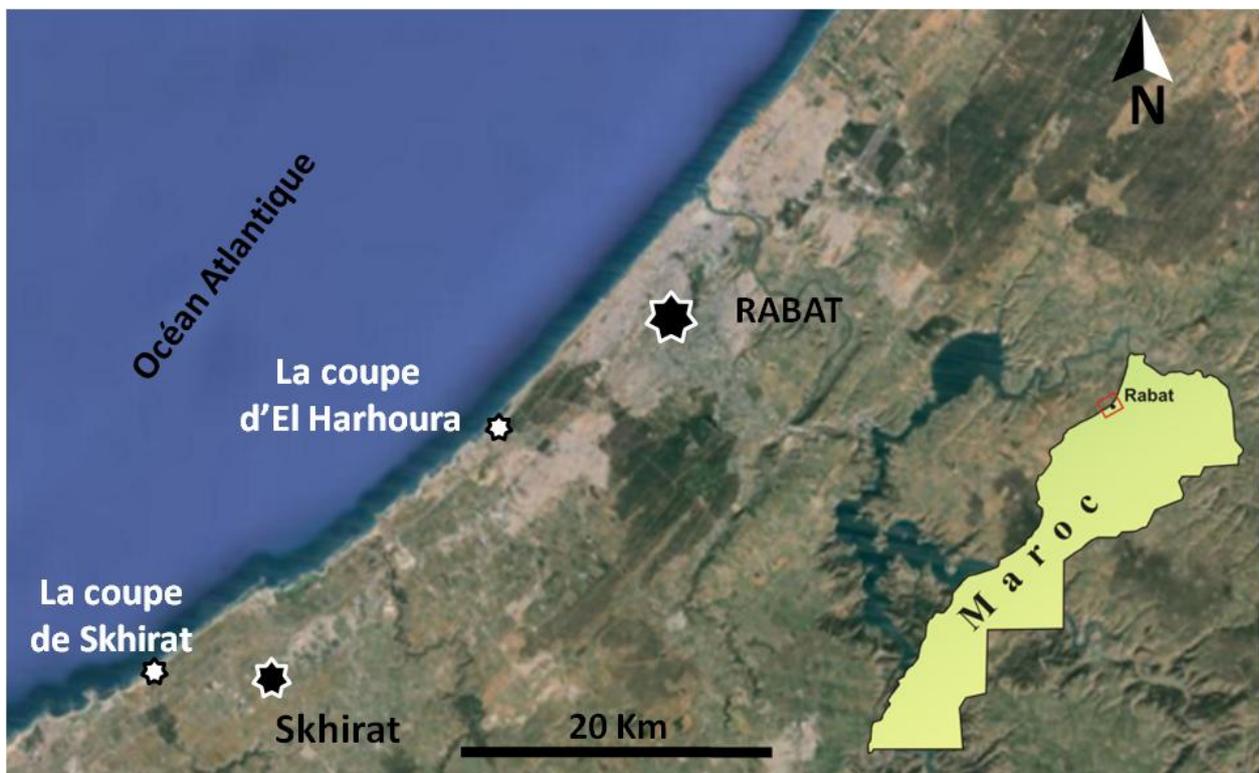


Figure 5: Holocene tsunamis and storms deposits at El Harhoura and Skhirat. (D. Chahid)



Figure 6: Geological sections of mid-sup Pleistocene deposits (D. Chahid)

### Surveys

On the field we have achieved a lithostratigraphic study of different coastal formations, and a discussion with experts: geologists, geomorphologists and geochronologists (figure 7).

Alongside our thesis project we participated in excavations and archaeological prospections. Thing that allows us to learn how to use the archaeological materials and techniques (for example Oulmès sites) and excavation work (the example sites Témara).

Also we participate in prospecting mission on the raw material and dyes in central Morocco. This last mission we improve knowledge in field of archaeo-materials.



Figure 7: Geological survey and sampling for datations, Témara region (photos D. Chahid)

### Results and publications

The identification and characterization of different facies of the coastal formations between Kenitra and Skhirat shows:

- The external Témara cord is formed by coalescence and juxtapositions of coastal dunes;
- The Oulja formed by a high-range marine deposit and units formed by rearrangements;
- The second cord between Rabat and Témara formed by the interlocking of several beaches (Middle Pleistocene);
- The identification for first time the presence of Holocene high energy deposits in Témara and Skhirat.

### Conclusion and Perspectives

The results have clarified a lot of issues but the absolute dates of important units could confirm first correlation based on the observation of the facies in the field and at the microscopic scale. Also verification of interpretations attributed to geodynamic condition (sea level relation, coastal dynamic) changes the landscape occupied by prehistoric men.

The application of the terminology of the stratigraphic sequence and the use of isotopic stages aim the objective to establish an understandable chronostratigraphic reference at a regional and a global scale.

## **1.3) Palaeoenvironmental context of the human occupations of the Témara caves based on microvertebrates**

Emmanuelle STOETZEL

### Introduction

Since several years, the microvertebrate remains of the Témara caves (El Harhoura 2 and El Mnasra) are studied with a pluridisciplinary approach (systematic, taphonomy, palaeoecology) in order to better understand the evolution of biodiversity, climate and landscape in this region in parallel with the human occupations of the caves and their taphonomic context. Excavations are still in progress in both sites, and consequently the microfauna sampling and study are still undergoing. But the results already obtained have shown the exceptional richness and interest of the Témara caves regarding small vertebrates, with more than 50,000 identifiable remains studied so far.

### Small vertebrate diversity

In total, more than 35 different species of rodents, shrews, hedgehogs, bats, amphibians (frogs, toads and tritons), tortoises and squamates (lizards and snakes) were identified in the Late Pleistocene and Holocene levels of El Harhoura 2 and El Mnasra. All are 'modern' species, and most of them are common in both sites (*Meriones gr. shawii*, *Mus spretus*, *Bufo mauritanicus*...). For certain species, the Témara remains represent the first, or the oldest description in North Africa (*Pleurodeles cf. waltl*, *Trogonophis wiegmanni*, *Coronella girondica*, *Natrix maura*) including Moroccan endemics (*Pelobates varaldii*, *Blanus* sp.) and species rarely described in fossil context (*Agama* sp.). But the Témara deposits have also recorded the presence of species today absent of this region, such as the Jerboa (*Jaculs cf. orientalis*, occurring today in more arid and eastern areas in Morocco), the Common toad (*Bufo spinosus*, occurring today in more humid and wooded/shrubby habitats, notably in the Atlas and Rif mountains) and, more striking, the Grass rat (*Arvicanthis* sp., occurring today in sub-Saharan savannas and in the Nile Valley). The distribution area of these species (which were not recorded in the same archaeological levels) has changed through time under climatic pressure.

### Taphonomic insights (figure 8)

A taphonomic analysis was carried out on the microfauna material from El Harhoura 2, and is almost complete for El Mnasra. The taphonomic signal is very similar in both caves concerning post-depositional alterations, despite few differences which could be due to the fact that the El Harhoura 2 excavations are done at the entrance of the cave, while at El Mnasra excavations are conducted deeper in the cave. Despite a small 'natural' component (animals that lived in or near the cave and died in situ), the main agent of accumulation in both sites is predation by different types of opportunistic predators (eagle-owls, diurnal birds of prey and/or small carnivores). In addition, during Neolithic there is also a possibility of human consumption of some small vertebrates (amphibians). The results of the taphonomic analysis argue for in situ accumulations with few or no perturbation after deposition (excluding well delimited burrows observed during excavations), and thus show a good integrity of the archaeological levels and a good palaeoecological representativeness of the small vertebrate assemblages.

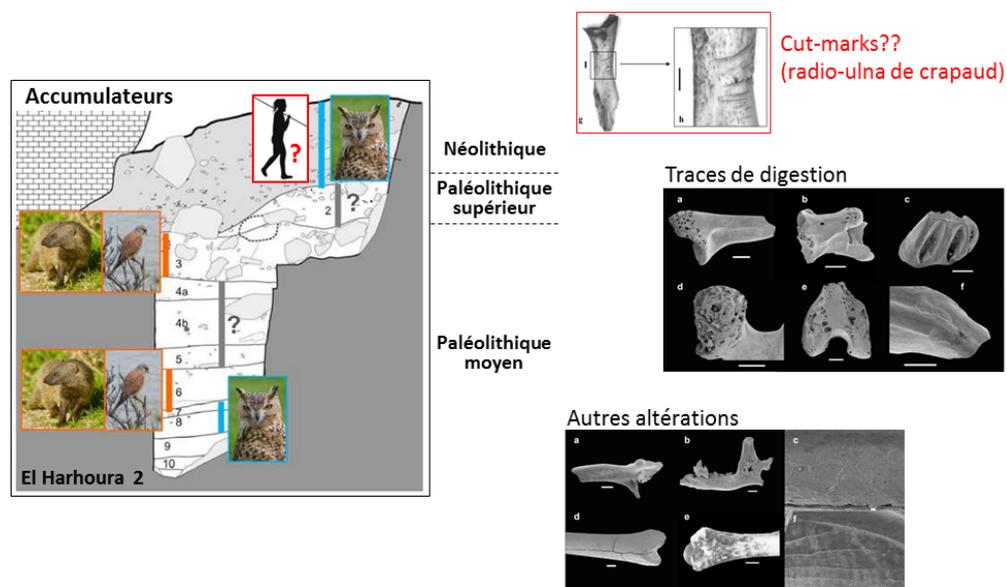


Figure 8: Synthesis of the Taphonomic analysis at El Harhoura 2 cave (E. Stoetzel)

### Palaeoenvironmental interpretations (figure 9)

The use of adapted palaeoecological indices based on both small and large vertebrates allowed to highlight in the El Harhoura 2 sequence an alternation of arid (levels 2, 5, 7; extension of arid steppe areas, decrease of vegetation cover) and relatively humid periods (levels 3, 4a, 6, 8; denser vegetation cover, more green, more wooded areas and freshwater ponds) throughout the Late Pleistocene, followed by a particularly humid period at the Middle Holocene (level 1; last climatic optimum). Regarding El Mnasra, the study is still ongoing but preliminary results confirm the chronological attribution of the level 3 to a dry phase of the Late Pleistocene (MIS 2? presence of Jerboa), while the level 6 is more complex to interpret, with the presence of a savanna rodent (*Arvicanthis* sp.) and an unknown gerbil (*Gerbillus/Dipodillus* indet.) which were not (yet) found at El Harhoura 2. The deepest levels of El Mnasra would be contemporary of MIS 5e (Eemian interglacial), but do not show significant differences with levels 3, 4a, 6 and 8 of El Harhoura 2.

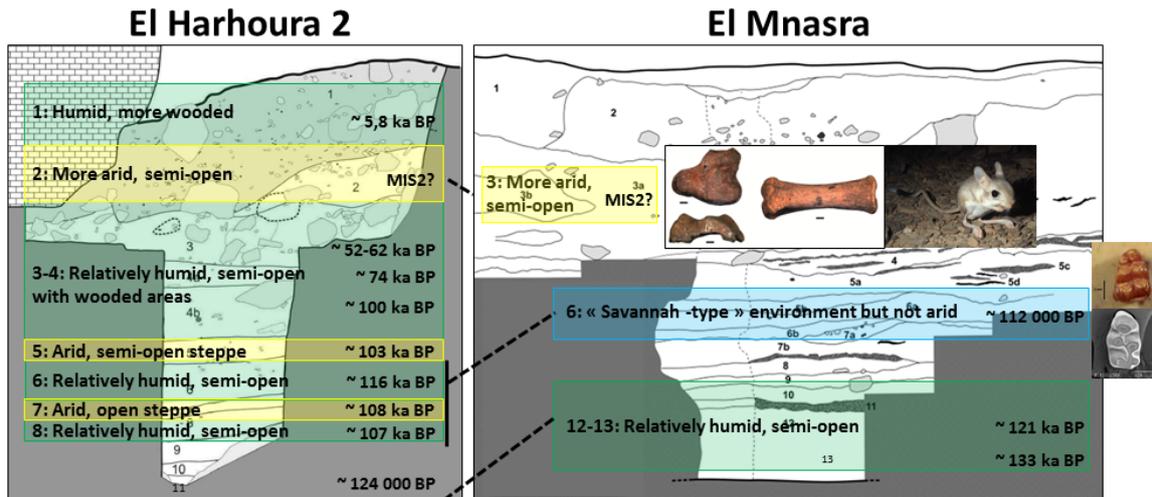


Figure 9: Synthesis of the Palaeoenvironmental reconstitutions at El Harhoura 2 and El Mnasra caves (E. Stoetzel)

#### A better understanding of human occupations

Through the palaeoenvironmental and taphonomic data that they provide, and in considering the other disciplines, microvertebrates can give information on the occupation of archaeological sites. Several climatic changes occurred during Late Pleistocene and Holocene at Témara, and more globally in Morocco and North Africa, with notable consequences on sea level which have probably influenced site occupations. It seems that El Harhoura 2 and El Mnasra were occupied episodically during Middle Palaeolithic (Aterian), especially during periods of high sea level, wetter climate and expanded grassland habitat in the Sahara, in alternation with periods of site abandonment, probably during drier periods. These human occupations alternated with several types of predators, accumulators of large and small vertebrates. As a real “cohabitation / competition” between humans and predators like owls is unlikely, the important small vertebrate accumulations, and thus the high predator activity in the cave, may confirm the hypothesis of a succession of short-term human occupations. In addition, it is interesting to note the presence at El Mnasra of the rodent *Arvicanthis*, now occurring in sub-Saharan savannas and in the Nile Valley. Some species of the genus *Arvicanthis* are today considered semi-commensal, living close to human habitations. Its presence at El Mnasra (level 6) during Late Pleistocene, and occasionally in other Plio-Pleistocene sites in Morocco, probably highlights environmental changes and migrations over long distances, through routes that could also have been used by human populations (along the Mediterranean or Atlantic coast, or through the Sahara during humid periods).

The emergence of the Iberomaurusian culture (Upper Palaeolithic) is contemporaneous with an aridification and a decrease in sea level during MIS 2, associated with a retreat of the coastline from 20 to 40 km at Témara, resulting in major changes in the environment and possibly access to marine resources by human populations. However, from the microfauna point of view, this MIS 2 aridification does not appear more pronounced than the previous dry periods of MIS 5, and it is likely that Témara has benefited from the buffer effect of the ocean, even during periods of low sea level. During the Holocene (El Harhoura 2, level 1), the study of large and small faunas indicates that no (or few) remains are attributable to domestic taxa and that no commensal species occurred. Thus pastoralism and agriculture were not yet developed in this region at that time. But Neolithic groups diversified their diet, especially towards marine resources including the great auk, and perhaps small vertebrates (amphibians).

Conclusion

Microfauna studies recently conducted at El Harhoura 2 and El Mnasra have strongly contributed to increase our knowledge of the palaeobiodiversity and palaeoenvironments of the Rabat-Témara region, contemporaneously to anatomically modern human settlements. This is the best known record for this period in North Africa, within well-established archaeological and chronological framework. Further studies will allow to go deeper in the interpretations, notably in using geometric morphometric methods to refine the biochronological and paleoenvironmental signal of North African micromammals, and isotopic analyses on rodent teeth conducted by colleagues from Oxford (Julia Lee Thorp, Amy Jeffrey) to refine the palaeoenvironmental changes through time.

**1.4) Human remains of Rabat-Témara region**

Aïcha Oujaa et Dominique Grimaud-Hervé

Excavations and Collections

As well as participation to archaeological excavations in the Rabat-Témara caves during missions (16th may- 2nd june 2013 and 18-31th May 2014) in Rabat, systematic inventory of neolithic human remains and new discoveries from M'Tsougatin 1 has been realized. Documentation is collected (morphological description, measurements and photographies). Total of 489 bones from El Mnasra and 252 (figure 10) from M'Tsougatin1 are documented in Data base which is going to be completed during next planned missions and be available to the scientific team.

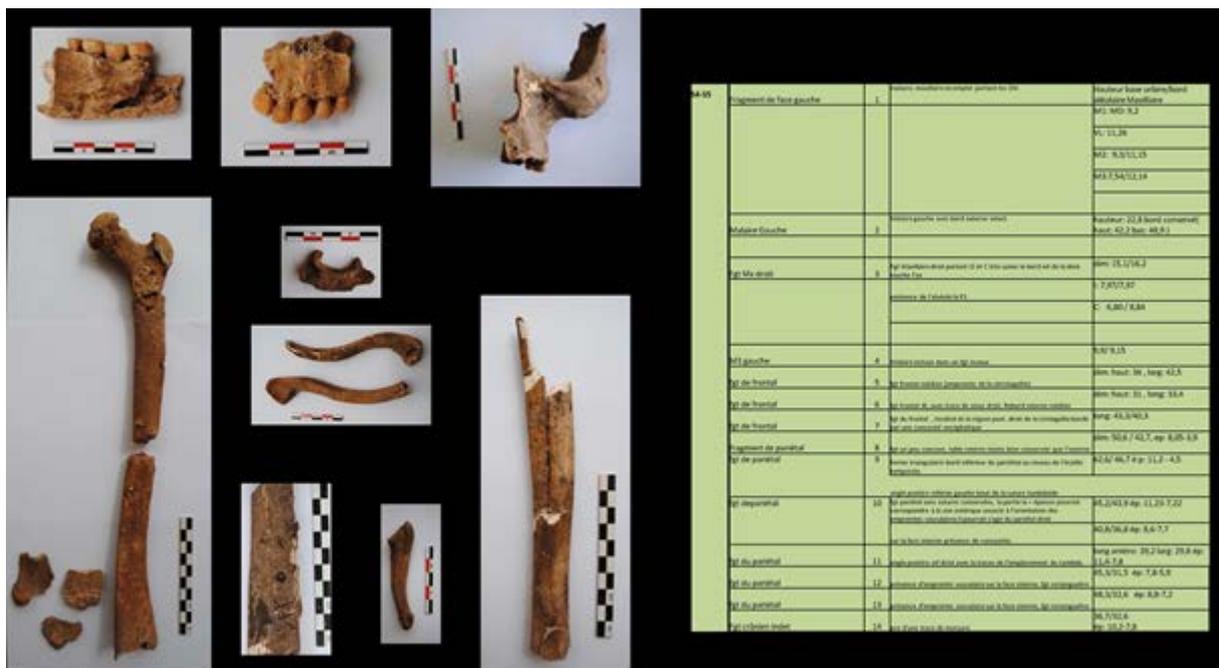


Figure 10: Examples of Neolithic Human remains studied from El Mnasra cave.

Forecast analyses

Geological revision of Rabat-Kébibat region is the opportunity to develop a new study of the human remains with a development of the internal cranial structures. This project, based on the systematic inventory of the human remains from this region, was started d Exchange CNRS-CNRST project is going until end of 2016.



## 2.2) Scientific results

The main scientific results carried out during the activity period of the MEMOQUAT project are related both to a better definition of the prehistorical occupational patterns and to the training of young scientist.

By the scientific point of view the main activities areas are located in the Tafilalt, in the Draa Valley and in the Ouazzane area. All investigate sites are open air sites and for this reasons an integrated approach (combining a petrographic, geomorphological and archaeological approach) have been utilized. The open air site are generally considered as complicates evidences, mainly because of the difficulty to state a chronology, but in some areas, as the ones explored during this project, are the only available ones. For those reasons, the aim of the project was to quantify the prehistorical occupation (during Lower and Middle Paleolithic), to relate it to the sources of raw materials and to the environment and to describe the technical behaviour of the prehistoric mans.

The project allowed to discover more than 30 new sits attributed to Lower (Acheulean) and Middle (Aterian and Mousterian) Paleolithic. The principal results and investigated areas are listed below.

### Tafilalt region

The survey activity in the Tafilalt region and in the Drâa valley (Sahara desert, South-East Morocco) started in 2007. The aim of the project was to create an archaeological-prehistorical map of the region and to a better define the Middle and Lower Palaeolithic of the area.

While problematic and often overshadowed by the scientific community, the study of surface deposits in desert environments (which are more numerous than those found in stratigraphic contexts) can provide interesting information, as long as factors that could limit and distort the interpretation of results are taken into account. The utilized approach has obvious limitations as the identified sites are open-air sites without any conserved stratigraphical sequence nor any faunal remains. Nevertheless, the homogeneity of lithic assemblages allowed us to obtain important information about the technical behavior adopted during the Middle Palaeolithic in the region.

During the years 2007-2014, five main surveys were organized and fifteen major sites were discovered and studied with a techno-economical approach.

In each site, the lithic materials were collected on an area of 6 m<sup>2</sup>, but a general analysis of the materials present in the whole area of highest concentration of lithic materials was also conducted in situ.

The chronology of the Tafilalt and Drâa Valley prehistorical occupation is not supported by direct datations because of the lack of a stratigraphic sequence or datable materials . However, the typo-technological characteristics allow the attribution of most of the sites of the Tafilalt to the Middle Palaeolithic (including the Aterian) and most of the Drâa Valley sites to the late Acheulean, associated to a Levallois production.

### Amane Oukider, anti-Atlas

The Amane Oukider site is located near the Tinghnir town in the middle of Anti-Atlas. The site is positioned near the raw material outcrop and near the Targuit oued at 1300 m on the sea level. The site covers an area of about 29.147 m<sup>2</sup>, with a maximum length of 232 m and a maximum width of 207 m. The analysed lithic material is coming by a non-exhaustive collecting of cores and flakes on all the site extension and by an exhaustive collecting on 1 m<sup>2</sup>.

The exploited raw material is fine and medium grained dolerite that outcrops directly in the site. The only attested method of debitage in Amane Oukider is Levallois, especially lineal and more rarely recurrent centripetal. All cores have big dimensions, with a length and a width ranging between 17 and 25 cm.

The lineal cores were exploited to obtain 4 different types of big Levallois flakes by direct percussion: lateral debordant flakes, lateral and distal debordant flakes, bi-lateral debordant flakes and non debordant flakes.

The reduction sequence is not complete in the site because the plain débitage phase is almost absent. All cores were abandoned after the detachment of just one preferential flake, probably due to the minimum dimension of researched products.

The centripetal recurrent production is made generally on flake-cores that have the same characteristics of the ones used for lineal production. The searched products have an elongated or triangular morphology and a dimension that is the half of preferential flakes. Also in this case a lot of researched flakes are lateral debordants and the plain débitage is absent. Each core has given a maximum of 6 flakes and it was abandoned after the first phase of production.

The lithic material coming from the exhaustive collecting show that the preparation of the cores was made on the site and it is coherent with the rest of studied material.

The big and standardized Levallois preferential flakes produced in Amane Oukider can be related with a secondary reduction sequence finalized to the façonnage of cleavers, as attested for many Saharan sites. The Levallois lineal flakes can so represent the blank for Type III ou IV cleavers.

The Amane Oukider site is a workshop finalized to a large production of big flakes by a Levallois method. Its localization is strictly related to the presence of raw material.

By a chronological point of view, the Levallois production associated to the Acheulian complexes in Morocco is linked by Biberson (1961) to the final Middle Pleistocene. Also if we can't obtain radiometric data for the Amane Oukider site and we can't make stratigraphical correlations, on the bases of the technological characteristics we can attribute the site to the final Acheulian or to the beginning of MSA.

#### Ain Dfali

The site of Ain Dfali is located in the south of Ouazzane city of, in the Northwest of the village Ain Defali. This area is situated at the western end of the Gharb plain in the southern area of pre-Rif tables. The Quaternary formations are located on the right bank of the river Redat. The large hills, at the West of Ain Dfali village, consist of alluvium gravel attributed to Early Quaternary. In the foothills the Middle Quaternary takes place with an attenuated highlighted.

The exploited raw material used to make the lithic industries, found on the site, consists mainly of quartzite with a choice of mid / big-sized blocks. The reduction sequences are not complete as demonstrated by the absence of preparation and small flakes.

Debitage and shaping reduction sequences coexist in this site. The shaping is essentially represented by handaxes and chopper-cores. Handaxes are often shaped on one side and show significant cortical residues; they are shaped on flakes elongated and flattened cobbles. The flakes used as blanks are generally cortical.

The chopper-cores are exploited by unifacial unipolar knapping (from 3 to 5 removals) and show a probably non-functional sinuous edge.

The utilized methods of knapping are Levallois (recurrent and lineal), discoid bifacial and unifacial and S.S.D.A. The S.S.D.A. method shows the exploitation of 2/4 knapping platforms by an unipolar method aimed at obtaining large / medium sized flakes with irregular shapes and often lateral cortical residues. Very few retouched blanks were found.

The Levallois débitage is done on flat and rounded cobbles, the preparation of the Levallois surface is carried out by centripetal knapping and the débitage surfaces show the detachment of a preferential flake, with a round shape, or a recurrent (centripetal or unipolar) exploitation; also documented is the production of Levallois points.

The discoid débitage is performed on rounded cobbles, it's mostly unifacial and it shows the preferential exploitation of a pronounced convexity or the alternating exploitation of two opposing convexities. The flakes obtained are thick and have a triangular / rectangular shape with converging negatives.

The material found in Ain Dfali is the result of a selective transport and is in the secondary position but allows certifying an important prehistoric Acheulian occupation in the region (figure 12)

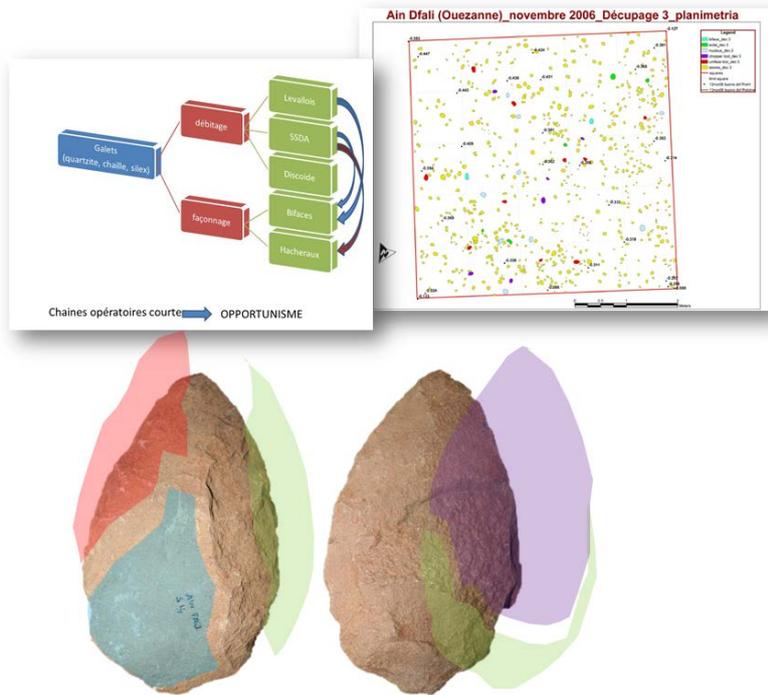


Figure 12: Chaînes opératoires and spatial distribution of lithic industry of Ain Dfali site.

### 3) PLEISTOCENE PALAEO-SEA-LEVELS AND NEAR-SHORE DUNES OF THE AGADIR COASTAL AREA, MOROCCO: IRSL AND U/TH DATINGS. GEOLOGICAL PROSPECTIONS AND CHRONOLOGICAL STUDIES

André WEISROCK, Sandra BALESCU, Abderrahmane OUAMMOU, Christophe FALGUERES, Bassam. GHALEB, Louis ROUSSEAU, Salah ABDESSADOK

#### Introduction

The Agadir area, north of the city, belongs to the Atlantic Atlas folded mountains, which are cut by a transverse coast. Capes are due to the main anticlines (Cap Rhir), bays to the main synclines (Tarhazout-Tamraght). All structures were planed along the coast by successive Pliocene and Pleistocene marine transgressions. So, coastal staircase terraces developed, reflecting both sea-level oscillations and tectonic uplift. More or less, each terrace, or UMS (« morpho-stratigraphic unit ») shows a basal marine deposit on the abrasion surface, under near-shore dunes and continental fluvial and colluvial deposits. Weisrock's previous geomorphological studies (1980 – 2012) recognised at least seven sequences, mainly: Holocene, « Ouljian » (= MIS 5), « Agadirian » (MIS 7 and/or MIS 9), « Maarifian » (MIS 11?), « Messaoudian » and two « Moghrebian » (Pliocene) uplifted terraces. Before 2010, only MIS 7-9 and MIS 5 were dated on shells by U/Th and by amino-chronology. Since 2010, our new research focused on using K-feldspar IRSL dating method on non-biotitic marine and aeolian sands, in order to establish a more complete and precise chronostratigraphy.

He aims of this work was to test IRSL and OSL methods on Ouljian and Agadirian formations and also to check the obtained ages with those obtained by U-series methods on shells.

MEMOQUAT program allowed us to undertake two land-trips:

- 2010, May, in order to test the IRSL method on MIS 5 and MIS 7 deposits. Following sites were sampled and dates obtained for Assif Tamraght Ns (MIS 5); Aghroud (MIS 5); Agadir-Founti (MIS 7) and Imzil (Pliocene?);

- 2013, November, in order to precise the chronology of MIS 5 with additional U/Th dates and to try first IRSL measures on the « Maarifian » (>MIS 9?) terrace. Following samples are to-day studied: Assif Tamraght Ns, Assif Tamraght Ss (MIS 5); Assif Lamahyane (> MIS 9).

#### MEMOQUAT 2010

##### 1) MIS 5 Palaeo-sea-levels (PSL) and near-shore dunes (NSD)

Several U-series dates using alpha spectrometry were provided recognised MIS 5 a (ca.72-75 ka) and maybe MIS 5 c (ca. 96 – 109 ka) for the Ouljian shoreline. This formation was sampled in different parts of the coast, for instance at Aghroud (+ 5 m asl for the sample). Basis = PSL with marine-shaped gravels and shells (a shell of *Thais (Stramonita) haemastoma* L. was sampled for U/Th but not yet available). Middle part: high beach and near-shore dune sands ; IRSL corrected age is  $91 \pm 13$  ka, i.e MIS 5 c. At Tamghart-Cape N (0 – 4 m asl). The features are the same as at Aghroud: PSL – NSD, but with two distinct successive NSD. Results at Tamraght-Cape N: Top of the PSL =  $81 \pm 8$  ka (IRSL corrected age): MIS 5 a or MIS 5 c ;  $91 \pm 9$  ka (OSL age) : MIS 5 c ; Second dune =  $63 \pm 7$  ka (IRSL corrected age) yielded a younger age suggesting maybe the MIS4...

##### 2) MIS 7 – 9 PSL AND NSD

At Agadir-Port-Founti, pointed out two PSL: MIS 7 or MIS 7/9 on a palaeo-beach deposit (ca. 180 and 250 ka); MIS 9 in a cave at the base of a dead cliff (ca. 275 ka).

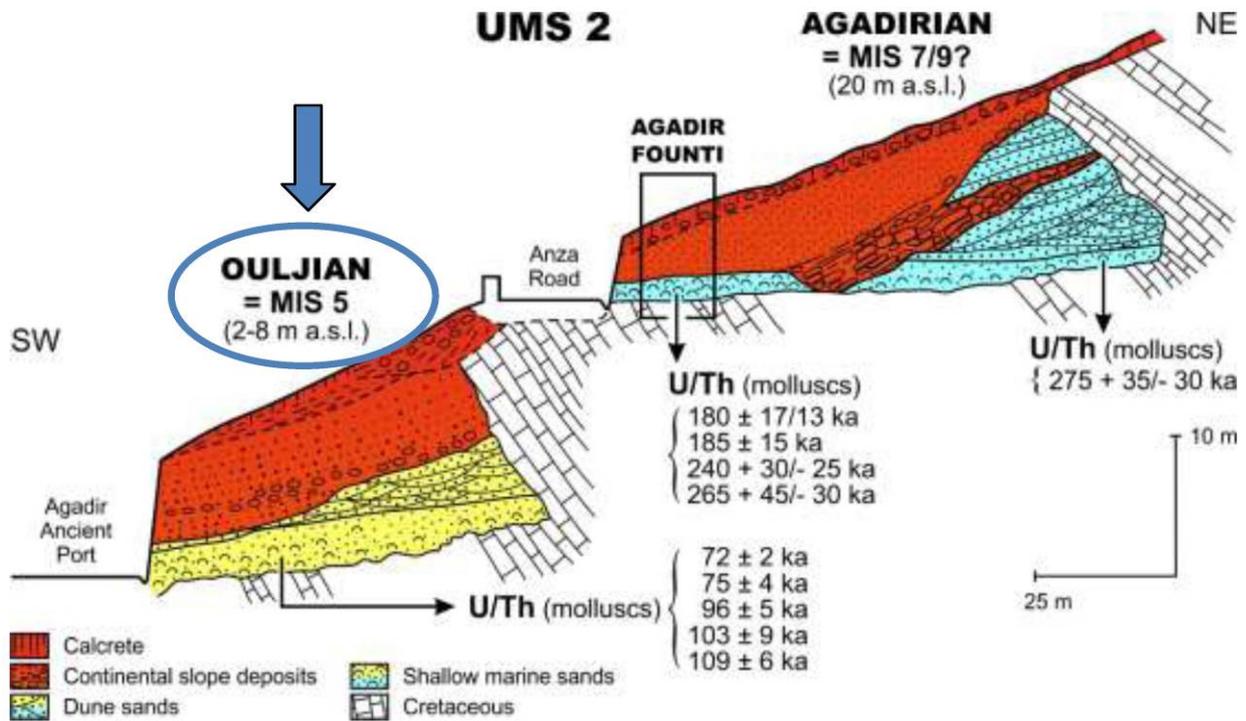


Figure 13: The Ouljian and Agadirian formations in the Agadir area.

Location	Sample	Reference	U/Th age (ka)	MIS
Imsouane NP	Ims 35	Hoang et al., 78	<b>179 ± 11</b>	<b>7 (?)</b>
AgadirPort	A. 127/3	Hoang et al., 78 ; Weisrock et al., 99	<b>180 ± 17/13</b>	<b>7</b>
Agadir-Port	A. 127-2	id	<b>185 ± 15</b>	<b>7</b>
Founti	F 3	Meghraoui et al., 98	<b>212 ± 18/16</b>	<b>7</b>
Founti	96 22-1	id	<b>234 ± 18/16</b>	<b>7</b>
Agadir-Port	A. 8-2	Hoang et al., 78 ; Weisrock et al., 99	<b>240 ± 30/25</b>	<b>7 ou 9 ?</b>
Agadir-Port	A. 127-1	id	<b>265 ± 45/30</b>	<b>7 ou 9 ?</b>
Founti	96 22-2	Meghraoui et al., 98	<b>267 ± 41/31</b>	<b>7 ou 9 ?</b>
Agadir-Port	A. 73/1	Hoang et al., 78 ; Weisrock et al., 99	<b>275 ± 35/30</b>	<b>9 ?</b>

Table 2: U-Th dates on the Agadir area for Agadirian formations.

Amino-Acid Racemisation of marine shells for MIS 5, 7, 9 at Casablanca were also provided suggesting that Agadirian stage could be contemporaneous of MIS7 or 9 and.

At Agadir Founti, sandy samples were taken in the PSL at two places (NE and SW, from ca. 50 m distant) and also in the NE dune. The corrected IRSL ages are  $180 \pm 36$  (SW sample);  $219 \pm 39$  ka (NE sample) for the PSL and  $227 \pm 43$  ka (NE sample) for the NSD. They clearly correspond to MIS 7. They

are in agreement with U-series dates ranging between 180 and 267 ka while RAA cannot choose between MIS 7 or 9.

### 3) « Moghrebian » (Plio-Pleistocene)

A sample of aeolian sand was taken in the megadune system of Imzil, more than 300 m asl. Its corrected IRSL age is  $> 1.43$  Ma.

## MEMOQUAT 2013

### 1) MIS 5 at Assif Tamraght



Figure 14: Ouljian deposits at Assif Tamraght north side.

Two fluvio-marine distinct sequences (PSL 1 and PSL 2) are overcome by a NSD. In PSL1 and PSL 2, marine shells were sampled for U/Th. Preliminary results are  $ca. 47, 0 \pm 0, 3$  ka for PSL 1 and  $76, 9 \pm 1,4$  for PSL2. These results do not agree with the stratigraphical sequence. However, the base of the dune sands gives an IRSL preliminary age of  $83 \pm 10$  ka, in good agreement with the U/Th age of PSL2. In the South side. The drawing shows the situation before 1980 : PSL 1 of the little cape was dated by U/Th at  $97 \pm 5$  ka = MIS 5 c (Hoang & *al.* 1978); in the following southern bay, a small Late Holocene terrace was built before the main « ouljian » infilling, wich is to-day strong eroded.

A recent study of the MIS 5 at Assif Tamraght South side, little cape where MIS 5 fluvio-marine PSL 2 deposit was sampled for U/Th datation. The preliminary result is  $81,6 \pm 0,7$  ka, indicating MIS 5 a, in good agreement with Assif Tamraght North side and A.T. -Cape results. An aeolian NSD was also sampled for IRSL study. The preliminary result is  $> 89 \pm 11$  ka. Beneath, a shell gives an U/Th preliminary age of  $107,2 \pm 0,9$  ka. These PSL and following NSD are clearly of MIS 5 ages.

### 2) « MAARIFIAN » AT ASSIF LAMAHYANE (+ 60 m asl) : MIS 9 ?

A study of the « Maarifian » exposures, at  $ca. + 60$  m asl was performed. A new road gives an outcrop of  $ca. 12$  m high. At the basis, a conglomeratic PSL lies on a marine abrasion surface developed in the Cretaceous limestones. Then, it is covered by 4 m of biotrititic well-bedded sands, with rare gravels and, in the middle part of the outcrop, by a 1 m thick grey coloured silts. Such deposits are known in Tunisia, where they are identified as lagoonal deposits (S. Balescu & H. Mejri, 2012). On the Atlantic

coast, it may represent a coastal infilling of the “oulja” in a low-energy environment. A sample of the grey silts gives a preliminary minimal, not corrected IRSL age:  $> 278 \pm 57$  ka (MIS 9 = 339 – 303 ka).

#### Preliminary conclusions

These field observations and sampling and the lab analyses which followed allowed a first elaboration of a chronological framework of marine formations in the Agadir northern part area.

The highest formation corresponds to the Moghrebian shoreline, at 300 m asl and dated to at least 1.4 Ma.

- The Maarifian shoreline at 60m asl is dated to more than 280 ka.

- The Agadirian formation, at 20 m asl, has given an age of beginning of MIS7 for the oldest part of this formation, and a range of 180 to 230 ka for the most recent part of this sequence, by three independent methods.

Finally, the Ouljian beach ranging between 2 and 5m asl, has been dated to MIS5 c and for the post-Ouljian dune, maybe at the beginning of MIS4.

#### **4) CLIMATE, HUMAN OCCUPATION AND TRAVERTINE DEPOSITS IN MOROCCO**

Louis Rousseau, Christophe Falguères, Jean-Pierre Pozzi, Mustapha Haddad, Lahcen Bejjit, Olivier Tombret, Larbi Boudad, André Weisrock.

And the scientific collaboration of Geoffroy Mahieux, Jacques Beauchamp, Abderrahmane Ouammou, Abdessamad Charif, Denis Fiorillo, Bassam Ghaleb, Bernard Lauriol

##### Abstract

We present the first results obtained by the study of Moroccan thermogene and meteogene travertine in 23 archeological sites distributed across the country. These technical analyses comprise  $^{14}\text{C}$ , TIMS and ESR dating, paleomagnetic,  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  measurements. The main information concerns the growth periods of both types of travertine (meteogene and thermogene), which are observed during both the glacial and interglacial stages of the global climatic chart during the Middle and Upper Pleistocene.

##### Introduction

Up until now, most of the North African travertine formations were attributed to the Pliocene period (Pentecost, 2010), due to the lack of dating. The same alleged period of growth was also proposed for Moroccan travertine. In Morocco, according to early geological maps, the travertine outcrops are attributed to Pliocene-Quaternary times, for instance; 1/500 000 (1952), and to the Lower Quaternary for more recent maps; Tafraout, 1/100 000; Taroudant 1/100 000 (1983). In southern France, travertine sites are dated to the Quaternary period (Fabre, 1986). Travertine dating provides a useful chronological framework for paleoclimatic archives as they can be dated accurately by uranium-series methods (TIMS, MC-ICPMS) up to an age limit of 500 – 600 ka (White, 2004) and by ESR. Travertine acts as a high-resolution recorder of the geomagnetic field when small amounts of ferrimagnetic minerals are incorporated in its crystalline structure. In the literature, glacial climatic conditions are generally associated with travertine growth (even-numbered marine isotopic stages). During recent periods, travertines were deposited in humid environments favorable to human occupation, as they provide water, abundant plant cover, animal food, and good strategic positions.

##### Sampling and methods

We sampled 23 sites distributed across the Moroccan territory (Figure 1). Seventeen sites are meteogene travertines and six sites are thermogene travertines. Each sample is oriented with respect to the North by a magnetic compass. Oxygen and carbon isotope analyses were carried out in the MNHN laboratory. The uranium-series dating method was conducted in two laboratories (UQAM and MNHN Paris). Dates with excellent reproducibility are obtained in the 5 to 500 ka range using mass spectrometry (alpha spectrometry and TIMS).

##### Results

Travertines are important markers during the Quaternary. Human occupation around travertines is discontinuous during the older periods (Acheulean) but becomes more continuous after 350 ka. In southeast Morocco, in the Tafilalet area, Mousterian flint fragments and cores (from 200 to 35 ka.) have been found at several travertine sites. A close link between travertines and human occupations has been established at several sites since the Mousterian: Aglou, Oued Noun, Iradi and Oued Assaka (Fig. 1). For more recent periods human occupation is also evidenced by Neolithic flint fragments (5000-4000 years B.P.) and tumuli (3000-1300 years B.P.) Travertine deposits are also present in the Oujda area (NE Morocco) with many artifacts. More recently, many modern cities are located on travertine sites (Fes, Sefrou, El Hajeb, Taza, Assads; figure 15). Human activity on these travertines is demonstrated by the presence of tumuli built in travertine stone (Lalla Mimouna), and also by villages perched on travertine formations (Iguiliz village).

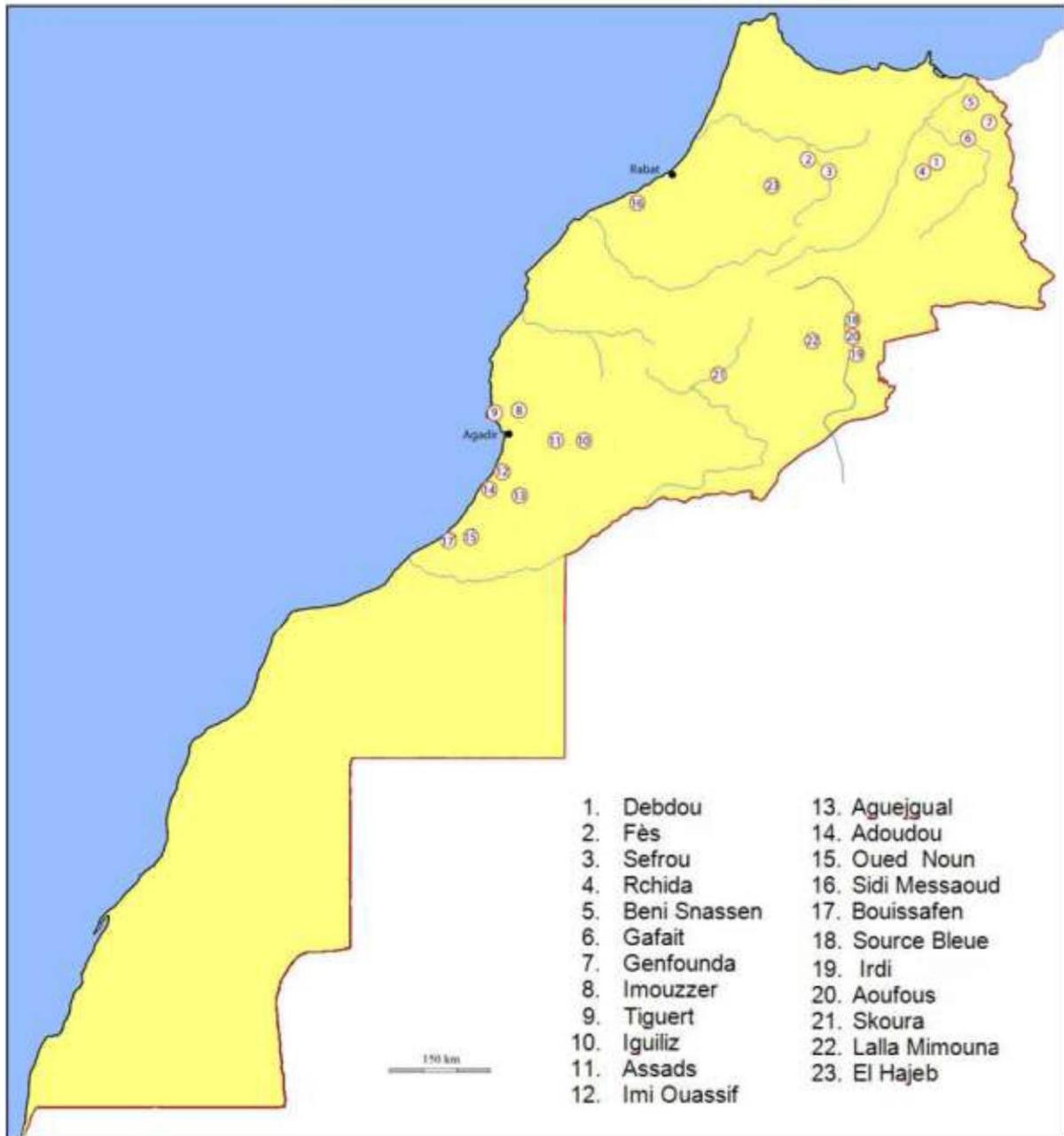


Figure 15: location map

Calcite growth stages can be dated using several radiochronological methods, extending from the present time until 500 ka with U-series, the  $^{14}\text{C}$  dating method, or paleomagnetic studies for older Pleistocene periods. For example, the Brunhes-Matuyama boundary has been identified in the Irdi travertine series, consequently attributed to MIS 19-1. Geochemical and paleomagnetic data align travertine formations within the Quaternary chronostratigraphic scale, which is then compared to the marine isotopic scale as a reference. Note that meteoene travertines are less suitable for geochemical isotopic studies and radiochronology than thermogene travertines due to their porous structure and their numerous impurities. The precision of travertine growth period dating allows us to place them without ambiguity in the isotopic stratigraphic time scale. The main result of the dates in table 1 is that travertine growth is effective during both glacial (or even-numbered MIS) and interglacial (odd-numbered MIS) stages. Growth rates vary between glacial and interglacial periods,

but in both climatic configurations, the periods of crystallization are well developed as they correspond to thick beds. Otherwise, we would not have been able to identify them.

Delta<sup>13</sup>C analyses provide additional information on meteogene travertines and thermogene travertines. Delta<sup>13</sup>C values for thermogene or meteogene travertines from Morocco are presented in figure 16. These values measured on thermogene travertines are about 13 ‰ higher compared to the mean values for meteogene travertine. These high values reflect rapid CO<sub>2</sub> evasion during the formation of the travertine and/or a magmatic origin for the CO<sub>2</sub>. The southern Moroccan sites (Irdi, Lalla Mimouna, Skoura, Assad) are located along the South Atlas faulting system. This structural setting complies with both mechanisms. On the same Irdi site, the delta <sup>18</sup>O results (figure 17) are in agreement with the bibliographical data.

In meteogene travertine, delta <sup>13</sup>C values reflect the type of vegetation in the C3 or C4 pathway. In the low-latitude areas of Northeast Africa, trees and shrubs use one form of photosynthesis, called the C3 pathway, to take carbon from the atmosphere and turn it into organic matter, while warm season grasses use a different form, the C4 pathway. For meteogene travertine, the mean values are different for each pathway: - 8 ‰ (C4) and - 2 ‰ (C3) (Pentecost, 2010). The values close to - 8 ‰ (versus PDB) indicate C3 plants, i.e., dominant tree cover whereas the values close to - 2 ‰ are generally associated with grass cover in the C4 pathway. All these delta <sup>13</sup>C values obtained in Moroccan travertines are consistent with the mean values computed for all the continents during geological periods. This correlation provides a good argument in favor of a thermodynamically closed system, and consequently for reliable dating.

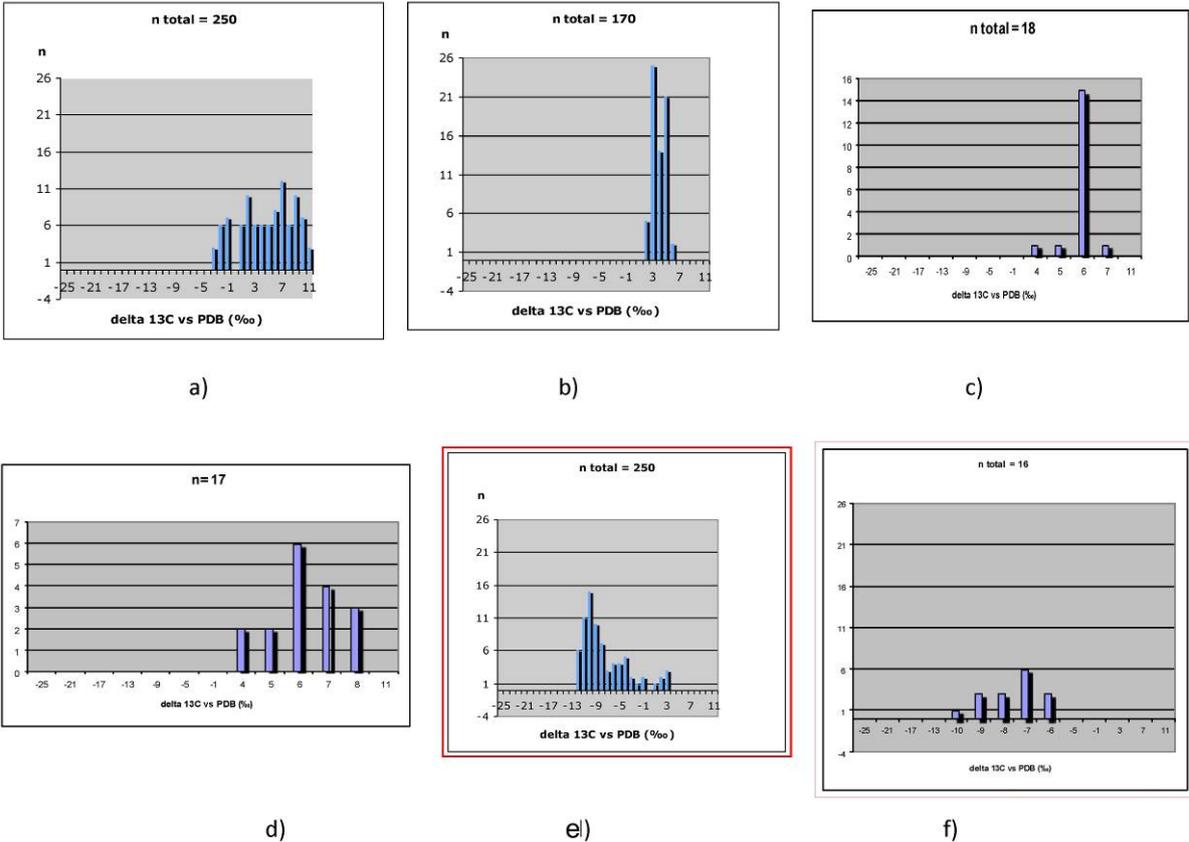


Figure 16: Distribution of delta <sup>13</sup>C of travertine formations. a) mondial repartition of thermogene travertine; b) Irdi site; c) Skoura 1 site; d) Lalla Mimouna site; e) mondial repartition of meteogene travertines, red frame; f) Skoura 2 site (red frame).

In order to plot the periods of travertine formation with respect to the global climatic chart, we selected seven sites where dating results were obtained with a good degree of precision (Table 3): MIS 1 (Iguiliz, Irdi), MIS 2 (Irdi, Sidi Messaoud, Fort Oued Noun), MIS 5 (Sefrou, Ouarzazate), MIS 19-1 (Bruhnes-Matuyama transition, Irdi). The deposition of thermogene and meteogene travertines occurs during both even and odd-numbered MIS.

M.I.S	Site	Dating methods	Sample	Datation (yrs)
<i>Meteogene travertine</i>				
MIS 1	Iguiliz	$^{14}\text{C}$	Coal	5690 BP $\pm$ 80
	Irdi	$^{14}\text{C}$	Shell	8800 BP $\pm$ 200
MIS 2	Fort Oued Noun	$^{14}\text{C}$	Coal	21600 BP $\pm$ 4000 24400 BP $\pm$ 1500
	Imouzzer	TIMS	Travertine	15400 BP $\pm$ 300
	Sidi Messaoud	TIMS	Travertine	27200 BP $\pm$ 6000
MIS 5.3 and 5.5	Sefrou	TIMS and ESR	Travertine	96000 BP $\pm$ 6000 108000 BP $\pm$ 4000 117000 BP $\pm$ 12000 129000 BP $\pm$ 5000 130000 BP $\pm$ 10000
				Ouarzazate
	Sidi Messaoud	TIMS	Travertine	109000 BP $\pm$ 6000 116000 BP $\pm$ 6000
	MIS 19.1	Imouzzer	Paleomagnetism	Travertine
<i>Thermogene travertine</i>				
MIS 2	Irdi	TIMS	Travertine	16800 BP $\pm$ 500
MIS 19.1	Irdi	$^{238}\text{U}/^{234}\text{U}$	Travertine	760000 BP $\pm$ 20000
		Paleomagnetism	Travertine	773000 BP $\pm$ 1000

Table3: periods of travertine deposition in 7 precisely dated sites.

A summary of dating records from north-eastern Africa provides important information if the 23 selected sites are representative of all the travertine growth periods in the whole of Morocco. In Morocco, precipitation occurs mainly during the Pleistocene to the Holocene periods and growth periods are observed during both glacial and interglacial stages of the global climatic context.

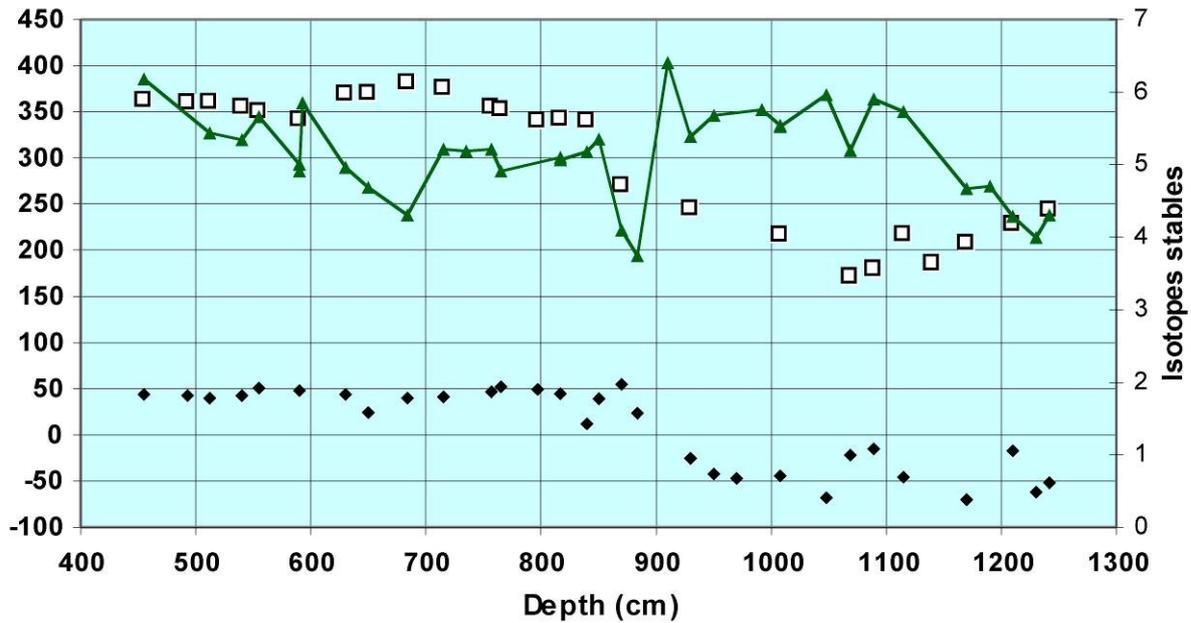


Figure 17: Distribution of  $\delta^{13}\text{C}$  thermogene travertine from Irdi site, between - 4 m and - 8m depth with superimposed inclinaison and declinaison memorized by magnetic minerals (green triangle :  $\delta^{13}\text{C}$  ; white square : declinaison and black diamond : inclinaison).

### Conclusion

- In the most favorable case brings metogene travertine paleoclimatical and hydrological information through Stable isotope studies.
  - Most of the travertine formations have developed during the lower end of the Pleistocene (around 1 Ma).
  - Magnetic inclination for the Irdi's core are consistent with the expected geomagnetic axial dipole (GAD) for this latitude) The core down inclination values indicate that the core contains a major portion of Brunhes episod and the Brunhes / Matuyama transition.
- In Morocco, forecast would be to study the speleothems identified into caves along the Atlantic Ocean, to compare the growth period between these two types of continental calcite formations.

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**MEMOQUAT (Man and Environments in Morocco during**  
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## WP2: LABORATORY WORK

### *I. Settlement of a dating lab at Meknes University*

#### **ESR and TL/OSL dating**

Lahcen Bejjit, Mustapha Haddad, Christophe Falguères, Nouha Janati

Since a few years, MNHN (Paris) and LASMAR laboratory (Meknes) work together for settling the ESR dating lab in Meknes. The "MEMOQUAT" program has allowed to the partners to develop this collaboration. Thus, the ESR measurements on samples of fossil teeth from prehistoric sites (El Harhoura and El Mnasra) and calcite from quaternary travertine (Agadir and Sefrou), were carried out in the two laboratories, IPH (MNHN) and LASMAR. The results were consistent and they have led to the dating of the sites above (*N. Janati Thesis, thesis under joint supervision between IPH and LASMAR*). The Ph D of Miss Janati (1992) has demonstrated the possibility to perform ESR dates at Meknes. The product of dose rate and time is the dose ( $D_E$ ) that the sample received from its burial to the present day. An ESR age is obtained by calculating the ratio of  $D_E$  and the annual dose rate. The first step has consisted in comparing the  $D_E$  obtained both at Paris and at Meknes. Results obtained were very convincing in terms of reproducibility showing that the ESR spectrometer of Meknes could yield accurate results (Table 1).

Echantillon	Données ESR-U/Th combinées			
	$D_E$ (Gy)		Age ESR-US (ka)	
	IPH	LASMAR	IPH	LASMAR
EH0601	39,3± 2,3	38,8 ± 3,2	92 +11/-9	89 ± 8
EH0603	28,5 ±1,6	34,8 ± 4,2	62 ± 4	72 ± 9
EM0604	44,2 ± 2,8	47,6 ± 4,7	89 ± 6	95 ± 11

Echantillon	Données ESR-U/Th combinées (signal h3)			
	$D_E$ (Gy)		Age ESR-US (ka)	
	IPH	LASMAR	IPH	LASMAR
EH0901	75,1 ± 10,3	67,52 ± 14,38	134 ± 27	118 ± 36
07SEF09	69,02 ± 1,3	95,5 ± 5	101,6 ± 10	140,6 ± 14

Table 1: Compared combined ESR-U/Th data between Meknes and Paris. Upper table corresponds to Teeth results. Lower table corresponds to carbonate results (travertine and marine shell).

Encouraged by this collaboration with MNHN on the dating, LASMAR has acquired, as a part of the pole of competence cultural heritage (2PC-Fes), a TL/OSL reader for the Luminescence dating (Figure 1). A training on this method, for members of LASMAR and University of Fes, was held as a result of a collaboration between MNHN, Montreal University (UQAM), Fes University and LASMAR. Preliminary measurements dating on sediments using quartz have been successfully obtained. A new collaboration has been also initiated with the CNESTEN of Kenitra concerning the artificial irradiations of samples which will be dated. Although LASMAR laboratory is not completely autonomous in ESR and TL/OSL dating, the knowledge transfer on dating, via "MEMOQUAT" program and other projects, from MNHN to LASMAR allowed LASMAR to be on the right track in this mission and to follow a solid collaboration between Paris and Meknes.



Figure 1: TL/OSL spectrometer RISO DA-20 model

## *II.Characterization of patrimonial and archaeological samples*

The second main purpose of WP2 was to reinforce the scientific collaboration for characterization of archaeological and geologic samples. In this frame, cultural heritage and archaeological materials were analyzed such as ceramics, glasses, mortars, pigments, coatings, paintings, manuscripts, teeth, excavation artifacts, Roman mosaics, coins, marble artifacts. For Geological materials, travertine, quartz, marble, limestone were analyzed.

### 1/Archaeological and geological samples Matthieu Lebon

In the framework of the MEMOQUAT program, we have initiated since 2012 the study of the pigments discovered in the Aterian archaeological levels of the El Mnasra cave (Témara, Morocco). The archaeological levels, dated more than 75 ka, have delivered more than 40 blocks of iron oxide pigments (hematite) and traces of pigments were also found at the surface of archaeological artifacts (shell *Nassarius sp.* and bone industry). The main purpose of this study is to determine the precise nature of these pigments in order to identify potential geological sources. This study also aims to identify traces of use on the surface of these objects to define the usage patterns of these pigments.

The study carried out between 2012 to 2014 have focused on the inventory and preliminary analyses of the blocks of raw pigment materials and stains of found on archaeological objects. We have also begun the identification of potential geological sources in order to establish reference collection for this geographical area.



Figure 2: Iron oxide found in Aterian levels at El Mnasra cave (Temara).

a ) Inventory pigment blocks and colored artefacts from Aterian layers of the cave of El Mnasra.

Fifteen samples of pigments were identified in Aterian levels before 2012. A complete inventory of archaeological material from previous excavations, including sieve residue, led to the identification of new samples of pigments. Currently, more than forty blocks of raw pigment are referenced in collection of Aterian levels of El Mnasra cave. In 2014, a preliminary study of ornaments (shells) was also initiated to localize the presence of pigment on these artifacts. More than 230 shells were examined. Pigment traces have been identified on approximately 16% of this material. A more specific study is ongoing on some of the material temporarily exported to France.

b) Identification of geological sources of pigment

In order to identify the potential sources of pigment available for prehistoric groups, it is needed to survey geological formations containing such materials in the more or less immediate environment of Rabat region. We initiate the survey of the geological formations on a transect line between Rabat and Oulmes in 2012. Fifteen samples of other sources have been collected in geological context but also in the bed of the Oued Bouregred which as its estuary located between Rabat and Salé. A more systematic survey of other sources accessible in the Rabat region was undertaken in early 2015 to allow the creation of more suitable geological references. Two significant sources of pigments, corresponding to old iron mines, were sampled at around forty kilometers east of Rabat.

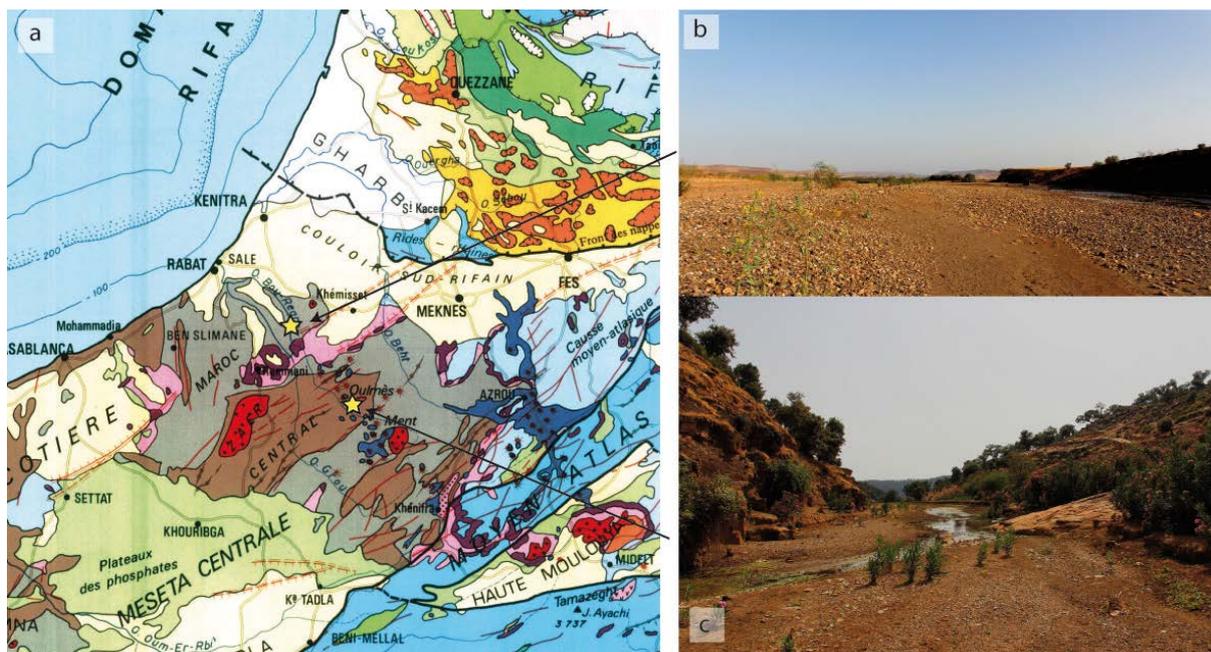


Figure 3: Geological map of the Rabat area. Two spots for collecting pigments were taken: b) in the bed of Bouregreg river and c) in the granitic hercynian upland of Oulmes.

#### c) First analysis of pigments at the LASMAR (Université Moulay Ismail - Meknes)

The exceptional value of the archaeological artefacts doesn't allow the realization of any sampling. All the steps of the analytical procedure have thus to be performed using non-invasive techniques. Several laboratories were contacted in Morocco, but unfortunately, none laboratory was equipped by the non-invasive analytical techniques needed for this study. On the basis of the first results obtained at the LASMAR, some of these samples were exported temporarily in France for further analyses.

A funding was obtained from Sorbonne University to allow the recruitment of a student as soon as April 2015 to take part to physico-chemical analysis of these samples. Several analytical techniques will be involved including micro-X-ray diffraction and X-ray fluorescence, micro-Raman spectroscopy and Ion beam analysis. This study will be realized in the first half of 2015 in collaboration with several laboratories in Paris (Pierre and Marie Curie University) and in Morocco (Moulay Ismail University).

#### 2/ Characterization and dating of cultural heritage materials of Morocco: A mobile analytical laboratory Project

Mustapha Haddad, Saadia Ait Lyazidi, Lahcen Bejjit

This project is of utmost importance in the frame of characterization combined to an optimal preservation of analyzed samples. (Some experimental investigations were performed in Paris during mobility stays in the MEMOQUAT framework.

#### a) Identification of indicators provenance's from the Moroccan marble.

Salam Khryssi, Mustapha Haddad, Lahcen Bejjit, Saadia Ait Lyazidi, Christophe Falguères

Twenty marble samples from different geographic areas of Morocco were studied. The main objective is to identify indicators to go back to the originating careers of marble in Morocco.

The technique of electron spin resonance (ESR) has been used primarily for its high sensitivity to identify crystal imperfections in marble stones; these imperfections are related to the presence of impurities or ionizing radiation sources in the marble career. The recorded ESR spectra showed the presence of several signals that are assigned to the main iron ( $\text{Fe}^{3+}$ ) and manganese ( $\text{Mn}^{2+}$ ) impurities. The shape of the  $\text{Mn}^{2+}$  lines has proved to be a good indicator of provenance because it strongly depends on the sampling career.

Quantitative elemental compositions were measured by X-ray fluorescence and the crystalline phases were determined by X-ray diffraction (Figure 3) and Raman spectroscopy techniques; calcite has been identified as major phase while quartz and kaolinite were identified as minor phases. Bands attributed to ferrous  $\text{Fe}^{3+}$  and ferric  $\text{Fe}^{2+}$  ions were recognized by optical absorption spectroscopy. The marble color, which mainly depends on both iron and manganese impurities contents, was measured by colorimetry.

The ESR results have been validated in the case of a Carrera white marble imported from Italy in the 18th century and collected from a historical monument of Meknes. The study is being extended to a larger number of marbles in view to create a catalog describing the typology of marble careers of Morocco.

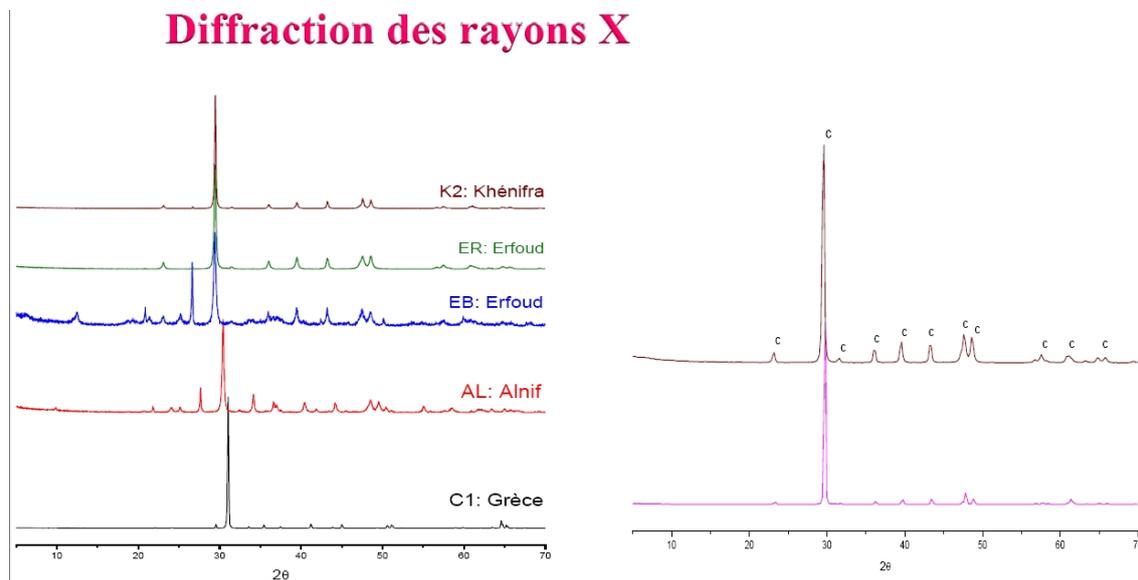


Figure 4: X-ray diffraction of analysed marbles with identification of calcite as main phase for Moroccan samples

#### b) Characterization of old Zelliges

El Amraoui Mohamed, Azzou Adila, Haddad Mustapha, Ait Lyazidi Saadia, Bejjit Lahcen

Samples of Zelliges originating from Dar-El Beïda Palace in Meknes (18<sup>th</sup> century), Al Mansour Palace in Meknes (17<sup>th</sup> century) and Al Badie Palace in Marrakech (16<sup>th</sup> century) were analyzed. The study was carried out on glazes of different colors. The colouring phases are identified by Raman spectrometry and the chromogen ions are identified by optical absorption spectrometry (OAS) and electron spin resonance (ESR). Identification of chromogen ions was accomplished, these ions are: copper ( $\text{Cu}^{2+}$ ) for the green, cobalt ( $\text{Co}^{2+}$ ) for the blue, iron ( $\text{Fe}^{3+}$ ) for the honey colour and iron ( $\text{Fe}^{3+}$ ) in association with manganese ( $\text{Mn}^{3+}$ ) for the black. Phases responsible of colour of glazes are determined: cassiterite ( $\text{SnO}_2$ ) for white, hematite ( $\alpha\text{-Fe}_2\text{O}_3$ ) for honey, hematite with magnetite ( $\text{Fe}_3\text{O}_4$ ) for black and dissolution of cobalt and copper respectively for blue and green glazes. Unmelted  $\alpha$ -quartz grains are used as an opacifier agent in the case of white, blue and green glazes. These data can be used to control and orientate some replication experiments in collaboration with Moroccan ceramics handcrafts.

c) Air pollution impact on Moroccan architectural heritage built in limestone  
Salim Foudeil, Hicham Hassoun, Taibi Lamhasni, Saadia Ait Lyazidi, Mustapha Haddad

The work focuses on the analysis of polycyclic aromatic hydrocarbons (PAHs) mixture adsorbed in black crusts deposited on the façades of two ancient Moroccan monuments built in calcarenite: i) the Burg al-klab tower of Salé dating back to the end of the 12<sup>th</sup> century and constructed during the Almohad period embodying Moroccan-Andalusian cross-influences, and ii) the Alqods Mosque of Casablanca (ancient Basilica Sainte Marguerite) dating back to the beginning of the 20<sup>th</sup> century. Both monuments are located near sea areas and just at few meters from traffic-bearing roads.

PAHs content of black crusts must be taken into account to establish intervention procedures and design security measures for workers protection during cleaning operations; PAHs are known mutagen and carcinogen.

In the present work, black crusts were taken at different points on the surfaces of the buildings; PAHs were extracted by dissolving the crusts samples in acetonitrile. Constant wavelength synchronous fluorescence spectra were carried out at many  $\Delta\lambda$  offsets, from 7 to 200 nm varied by 1 nm step; they permitted the identification of the sixteen most hazardous PAHs in the black crusts sampled on the investigated monuments. These substances were classified in seven groups according to their fluorescence peaks positions: i) Fluorene and Naphthalene appearing in the emission wavelength range 300 – 325 nm, ii) Acenaphthene appearing in the emission wavelength range 325 – 350 nm, iii) Pyrene, Phenanthrene and Chrysene appearing in the emission wavelength range 350 – 375 nm, iv) Anthracene, Benzo(a) anthracene, and Dibenzo (a,h) anthracene appearing in the emission wavelength range 375–400 nm, v) Benzo (a) pyrene, Benzo (b) fluoranthene, Benzo (k) fluoranthene, Benzo (g, h, i) perylene and Fluoranthene appearing in the emission wavelength range 400 – 435 nm, vi) Perylene appearing in the emission wavelength range 435–455 nm and vii) Indeno (1, 2, 3 – cd) pyrene appearing in the emission wavelength range 455-485 nm.

Although the investigation is only qualitative, considering the remoteness of the studied buildings, the analogy of the identified PAHs groups in both historical sites implies that the origin of the organic pollution, by the hazardous PAHs, is very likely the same; the edifices are exposed to high traffics.

d) Non invasive multi-technique study on colored materials of ancient Moroccan Manuscripts  
Abdelmajid EL Bakkali, Saadia Ait Lyazidi, Mustapha Haddad

A rich and non invasive multi-technique study has been carried out on two ancient Moroccan Islamic manuscripts anterior to 150 years. These manuscripts, with different supports, shapes and decorations, dealing with theology, belong to different ancient scribing schools of the western Arabic Mediterranean region. Currently, Moroccan manuscripts investigations are limited to codicological studies in which reports on illuminations and colored vocalizations are limited to visually descriptions. Hence scientific investigations are required for an objective characterization of this universal heritage.

The integration of elemental and molecular information acquired by XRF, XRD, micro-Raman, SERS, reflection FTIR, reflection UV-vis, UV-vis fluorescence (steady state and time resolved), has allowed for the characterization of both inorganic and organic pigments. The inorganic pigments have been identified and characterized by combining the elemental XRF information with molecular infrared and Raman investigations. XRD analyses have been also carried out for the identification of the crystalline compounds. Vermillion, orpiment, azurite, lead chromate, emerald green, Scheele's green and artificial ultramarine were identified. Red and yellow organic pigments have been identified by combining SERS, reflection UV-vis, and UV-vis fluorescence (steady state and time resolved) spectroscopic techniques. The signals detected on red colors were assigned to the animal carminic anthraquinone, while those detected on yellows seem originating from a natural flavonoid. The present study, which is the first complete one undertaken on ancient Islamic documents of Morocco, is being extended in situ to other artworks unique in the Islamic world and available at the Moroccan libraries.

**PEOPLE MARIE CURIE ACTIONS**  
**International Research Staff Exchange Scheme**  
**Call: FP7-PEOPLE-IRSES-2008**  
**MEMOQUAT (Man and Environments in Morocco during**  
**Quaternary)**

## WORKING PACKAGE 3: TRAINING

### PLAN

1. TEACHING AND TRAINING
2. ACADEMIC PHD
3. DISSEMINATION AND PUBLICATIONS
4. TERMS
5. SCIENTIFIC PROGRAMS AND CO-FINANCED PROJECTS RELATED TO MEMOQUAT PROGRAM

*The Mobility Memoquat Programme, during more than 4 years, has fostered several lines allowing an implementation of collaborations between Moroccan teams and Italian and French teams.*

### 1. TEACHING AND TRAINING

- The creation of a Master of Prehistory at Meknes University was an important point in terms of training for our programme. Unfortunately, this speciality was disused because too few students were registered and the number of teaching hours were cancelled. INSAP partner allowed a new opportunity for teaching and training students.
- Field Summer Schools were regularly organized on the Rabat-Témara including sites excavations , archaeological methodology, Archaeological Museum and Sites visits, were a mean of 20 INSAP students and at least 4 or 6 French students from MNHN could participate each year.
- In the Paris Master “Évolution, Patrimoine Naturel et Sociétés, Spécialité « Quaternaire et Préhistoire : Paléoenvironnement, Lignée Humaine, Histoire des Sociétés (QP)”, a module entitled “Prehistory of Northern Africa” is organized each year and in which 3 moroccan profs teach and participate to the evaluation of the students.
- **Prof Aïcha Oujaa** participated to the master training about Prehistory of North of Africa in the tree thematic (*Homo erectus* and Anatomical Modern Humans, Neolithic Funeral Rituals, Protohistoric Monuments and Funeral Rituals) beneficiating to the MNHN students master in Quaternary and Prehistory.
- **Prof Dominique Grimaud-Hervé** accomplished in Morocco seminars for students enrolled in INSAP Prehistory training with two thematic concerning first settlements of continental and insular Asia and settlement of Eurasia with the first out of Africa : Dmanisi.  
Intervention and discussion with children from “El Qods” school in Rabat about “Evolutive tree of fossil hominins”  
Prof DGH participated to supervision of Khadija Belamine, Moroccan PhD in Sciences and Techniques University (Fez), and to bibliographic researches on funeral monuments and rituals.
- A collaborative supervision (**AO, DGH, RN**) of master between French and Moroccan teachers for Xavier Sens entitled “Biological and Cultural study of human remains from M’Tsogatin 1 (Oulmès, Morocco)”.

## 2. ACADEMIC PHD

The formation of PhD students is one of the most important goals in the Memoquat programme. Three students defended their PhD since 2011 and one will defend his PhD up to the end of 2015.

Phd defence of Nouha Janati, may 2012 at University of Moulay Ismail, Meknes, « Développement de la méthode de datation par Résonance de Spin Electronique (ESR) : applications sur des matériaux archéologiques (sites de la région de Témara) et géologiques (régions d'Imouzzer Ida Outanane, Sefrou, Irdi) du Maroc ».

PhD defence of Hamed Ain Touchnt, “Petroarchaeology of the Lithic Industries Found on Superficial Lower and Middle Palaeolithic Sites of South Eastern Morocco - Using Petrographic and Geochemical Approaches” – passed at the University of Ferrara in 2012 - Doctorate in “Scienze e Tecnologia per l’Archeologia e I Beni Culturali”.. This work is the result of a long and fruitful collaboration between italian and moroccan teams.

Phd defence of Houda Oudouche “Le débitage sur éclat dans la Méditerranée occidentale durant le Paléolithique moyen: Abric Romani (Capellades, Espagne) et Ifri n’Ammar (Rif oriental, Maroc)” - passed at the University of Ferrara in 2015 - Doctorate in “Scienze e Tecnologia per l’Archeologia e I Beni Culturali”.

Driss Chahid is a Phd student under the supervision of a Moroccan and a French Profs. The topic of his Phd is: “Chronostratigraphie et dynamique de mise en place des formations quaternaires littorales du Pléistocène moyen final et du Pléistocène supérieur entre Skhirate et Kénitra”. He will defend his Phd at the end of 2015 at Meknes University.

### 3. DISSEMINATION AND PUBLICATIONS

**3.1. The Memoquat Website** is available since 2011 to this permanent link:

<https://sites.google.com/a/unife.it/memoquat/home>

#### 3.2. Conferences

A regular conference cycle was opened at Meknes University where French and Italian researchers present their results and methods used either on the field or in the lab to the Moroccan students and attracting them to apply to the Erasmus Mundus in Quaternary and Prehistory (IMQP) Master. In 2014, another conference cycle has begun at INSAP of Rabat.

#### 3.3. Meetings, colloquiums and publications

One international colloquium and two workshops were organized in close collaboration with Memoquat programme.

- The “Journées francophones” were held in October 2013 in Paris and the scientific program can be seen in Annex 1.

- In November 2014, a presentation of the work of PhD Meknes students was organized and followed by a cycle of conferences presented by L. Rousseau and C. Falguères from Paris. Last March, a workshop for closing the Memoquat program was held in Meknes. All the oral presentations are available for consultation in Annex 2.

The RQM 6 and 7 (Moroccan Quaternarist Meetings) were the main events were presented our results.

- Communication at the colloquium of moroccan quaternarists RQM6 (Tangier, Morocco) in 2011
- Communication at the international symposium GIS users (Fes, Morocco) in 2012  
Communication at symposium tunisian quaternarists ATEQ1 (Tunis, Tunisia) in 2012
- Communication at Francophone Days (Paris, France) in 2013
- Communication at the colloquium of moroccan quaternarists RQM7 (Agadir, Morocco) in 2013
- Communication at the french quaternarists colloquium Q9 (Lyon, France) in 2014
- Publication of an Article in acts of the RQM6 colloquium
- An article in correction for the *Geomorphology Journal*
- An article in correction for the *Quaternary Journal*

See also Annex 3:

1. Articles in peer reviewed journals (n=22 plus 4 accepted and 9 submitted)
2. Books, book chapters and conference proceedings (n=11)
3. Academic PhD (n=5)
4. Conferences, seminars communication (n=75)

### 3.4. 2014 final meeting of MEMOQUAT program, Meknes, Morocco

#### PROGRAM

##### Journées MEMOQUAT

(Man and Environments in Morocco during Quaternary)

##### Restitution, synthèse et perspectives

Les 6 et 7 mars 2015

Université Moulay Ismaïl

Faculté des Sciences, Meknes, Maroc

##### Vendredi 6 mars

9h : Accueil des participants

9h15 – 10h45 : Fouilles et recherches Maroc Atlantique

Intervenants : Roland Nespoulet, Mohamed Abdeljalil El Hajraoui, Aïcha Oujaa, Dominique Grimaud-Hervé, Christophe Falguères, Brahim Ouchaou, Driss Chahid, Bouchra Bougariane

10h45 – 11h : Pause thé

11h – 12h30 : Fouilles et prospections

Intervenants : Marta Arzarello, Larbi Boudad, Roland Nespoulet

12h30 - 14h : Repas

14h30 -16h Etude des carbonates marins et continentaux

Intervenants : Louis Rousseau, Christophe Falguères

16h -16h15 pause thé

16h15 -18h30 : Analyses en laboratoire

Intervenants : Matthieu Lebon, Saadia Ait Lyazidi, Mustapha Haddad, Lahcen Bejjit, Mohamed El Amraoui, Salam Khriissi, Abdelmajid El Bakkali

##### Samedi 7 mars

9h -10h30: Formation et enseignement

Intervenants : Christophe Falguères, Roland Nespoulet, Abdessalam Mikdad, Matthieu Lebon, Olivier Tombret

10h30- 10h45: pause thé

10h45-12h30: Formation et enseignement

Intervenants : Mustapha Haddad, Larbi Boudad, Saadia Ait Lyazidi, Lahcen Bejjit

12h30-13h : Clôture

13h00 - 14h : Repas

Après-midi : Sortie



Participants of Final meeting of MEMOQUAT program, Meknes, Morocco, 2015, March, 7

#### 4. TERMS

- Miss **Bouchra Bougariane** accomplished here mobility during one month with two main objectives: access to the comparative anatomy collection which is missing in Morocco and participating at international conferences. She also worked on bibliographic documentations to complete her knowledge and help for the dissemination of her work. This mobility allowed Miss Bougariane, by working on new research methods, to extend her scientific network in the fields of paleontology, archaeozoology and prehistory, and to initiate new scientific collaborations.

- Miss **Wafaa Zriouel** has done training in the Department of Prehistory from January 20 to February 1<sup>st</sup> 2013. Wafaa Zriouel is engineer at the CNRST of Rabat, and she is in charge of the vibrational spectroscopy platform. The purpose of her training was the study of our preparation protocols for mineralogical, archaeological and geological samples and to compare this technique to those used in her laboratory. During her visit, she was also trained to the analysis of samples by infrared micro-spectroscopy. Such an analytical device was recently acquired by the CNRST in Morocco but a specific training is required for the use of this technique and the treatment of the spectral data obtained by this molecular imaging technique. This will reinforce the synergy between the LASMAR and CNRST laboratories.

- **Olivier Tombret**: Training in geochronology: *in situ* dosimetry highlights, and experiences in Morocco. Sampling and gamma spectrometry analysis throughout two weeks of fieldwork. The two CNRS Research units, UMR7194 (Histoire naturelle de l'homme préhistorique) and UMR7209 (Archéozoologie, Archéobotanique, sociétés pratiques et environnements) fo which I share myl work within both are involved in the interactions between humans and their environnement during the Pleistocene and Holocene. Studies within these eras depend on chronological markers and therefore abundant dating of samples. Radiocarbon dating and ESR/U-Th combined dating are the used methods. The latter is primarily used for the dating of teeth during the Pleistocene, and I will focus on this method for this report. The combined ESR/U-Th dating method involves many different steps, so the process has a lengthy preparation and processing time before results are obtained. Each step is absolutely necessary, and stages include on-site analysis in the field, and the collection of samples for data on analysis parameters. Involvement in fieldwork is important when using this method, as in order to understand the method completely it is necessary to have personal experience undertaking all stages of analysis. The MEMOQUAT program played a fundamental role in enabling my visit to Morocco, providing me the opportunity to complete the final part of my training. The fieldwork and training occurred as part of one of the excavation sessions of the Rabat/Temara archaeological sites. There are three primary aims of fieldwork in respect to the ESR/U-Th combined dating methods, the first of which is *in situ* gamma spectrometry analysis. The purpose of this step is to obtain a representative measure of the sediment gamma activity that acted on the tooth (gamma dose). The data is collected from a sphere of sediment around the tooth, estimated at 60cm in diameter, and this depends on the homogeneity or diversity of the sediment composition. The training for this method was undertaken with Dr. C. Falguères.

The second aim of fieldwork is to collect sediment from the layer associated with the tooth for high-resolution gamma spectrometry analysis in the laboratory. This will provide data on chemical content for the preparation of the steps that follow, and for the calculation of the beta dose, one of the parameters necessary for the age calculation.

The third point is the measurement or estimation of the sediment thickness above the tooth discovered. This is necessary to calculate the cosmic dose, another one of the parameters to calculate the age.

During the fieldwork four sites were analysed by *in situ* gamma spectrometry. These were the El Harhoura 2 cave with Dr. C. Falguères (UMR7194), the Carrière 10 site along the coast between Rabat and Temara with Pr M. Lamothe (UQAM, Montréal), and the Sidi Moussa cliff base at the north of Sale and El Mnasra cave with D. Chahid who benefited also of this field training (PhD student, MNHN).

The data collected during this mission allows the calculation of new ESR/U-Th teeth dates and OSL dates of sediment. This is necessary to enrich the knowledge of the chronology of human occupation along the Moroccan coast during the Quaternary.

## 5. SCIENTIFIC PROGRAMS AND CO-FINANCED PROJECTS RELATED TO MEMOQUAT PROGRAM

The MEMOQUAT program has additionally permitted further excavation campaigns, the development of collaborations between Moroccan, Italian and french colleagues, and new subject matter for master theses, and new research programs.

→ The development of scientific, technical and academic relations and projects among the partners is the direct result of dynamic initiated by the Memoquat program during the last 5 years.

Other projects have also been conducted in direct connection with Memoquat Project:

### 5.1. Mission archéologique El Harhoura-Témara, France-Maroc (projet quadriennal 2011-2015)

*Resp. : R. Nespoulet, MNHN, Département de Préhistoire, UMR 7194 du CNRS, Paris, France ; M. A. El Hajraoui, Institut National des Sciences de l'Archéologie et du Patrimoine, Rabat, Maroc.*

La mission archéologique El Harhoura-Témara a été créée en 2001.

Ses travaux portent sur les grottes et leur environnement dans la région de Témara, près de Rabat, sur la façade atlantique du nord du Maroc. Depuis 2001, les fouilles concernent les grottes d'El Harhoura 2 (coord. N 33,95, W 6,93) et d'El Mnasra (coord. N 33,93, W 6,95), qui font partie d'un ensemble de 6 grottes principales situées sur une bande littorale d'une dizaine de kilomètres entre les villes de Rabat et de Témara.

Les fouilles ont permis de mettre au jour une nouvelle séquence stratigraphique à El Harhoura 2, de préciser la séquence stratigraphique d'El Mnasra, et d'apporter une nouvelle documentation archéologique, paléontologique et paléoanthropologique exceptionnelle : la quasi-totalité des vestiges d'*Homo sapiens* atériens d'Afrique du Nord ont été découverts dans la région de Témara, correspondant à des occupations humaines et non-humaines (carnivores) que l'on peut situer chronologiquement, grâce aux nouvelles datations réalisées ces dernières années, entre -130 000 et -4 000 ans.

Les résultats obtenus apportent des informations capitales sur le contexte paléoenvironnemental) et les modes de vie des plus anciens Hommes modernes connus en Afrique du nord, sur leur origine, l'évolution de leurs cultures et leur dispersion. Grâce à la dynamique des recherches engagées, nous avons la possibilité de développer pour la première fois une étude régionale et inter-sites, dans une région de référence de la Préhistoire du Maroc.

Nous proposons ainsi un nouveau modèle de peuplement plus complexe, où les relations hommes-environnements constituent l'approche privilégiée. À l'échelle régionale de Témara, il existe un lien entre climat et peuplement : les périodes interstadias (hauts niveaux marins) correspondent aux principales occupations humaines, alors que les périodes stadias (bas niveaux marins) correspondent à l'abandon des cavités par les hommes, le plus souvent au profit d'autres prédateurs (Carnivores). La question posée est alors de savoir si ce modèle régional est spécifique à son milieu (littoral atlantique, faible altitude) ou peut être retrouvé dans d'autres régions.

### 5.2. Programme ANR « La 6<sup>ème</sup> extinction » (2010-2014)

*Resp. : C. Denys, MNHN, Département systématique et évolution, UMR 7205, Paris, France. Partenaire 2 (Préhistoire) : R. Nespoulet, MNHN, Département de Préhistoire, UMR 7194 du CNRS, Paris, France ;*

Ce programme intitulé « Influence de l'installation des hommes modernes au Maroc sur l'évolution de la biodiversité des petits vertébrés terrestres » (acronyme « MOHMIE » d'après le titre en anglais

« Modern Human installation in Morocco Influence on the small terrestrial vertebrate biodiversity and Evolution ») propose une approche multidisciplinaire inédite. Son objectif est de comprendre les effets de l'arrivée et de l'installation des premiers hommes actuels (*Homo sapiens*) depuis 120 000 ans au Maroc sur les communautés de petits vertébrés terrestres (rongeurs, musaraignes, amphibiens et lézards) par : (1) l'étude des fossiles des 23 niveaux stratigraphiques allant du Pléistocène supérieur à l'actuel des grottes de la région d'El Harhoura-Témara près de Rabat et (2) l'étude de la biodiversité actuelle, de la biogéographie et de la génétique des populations dans des environnements naturels et perturbés.

### **5.3. Programme « Peuplement préhistorique du Maroc atlantique », CNRS-CNRST (2014-2015)**

*Resp. A. Oujaa, Institut National des Sciences de l'Archéologie et du Patrimoine, Rabat, Maroc. ; D. Grimaud-Hervé, MNHN, Département de Préhistoire, UMR 7194 du CNRS, Paris, France.*

Le projet de coopération CNRS-CNRST intitulé « Peuplement préhistorique du Maroc atlantique » déposé en septembre 2013 a été retenu pour financement. Ce projet scientifique anthropologique traite de questions inédites dont le principal objectif est de préciser la position phylétique des hominins fossiles de Rabat-Kébibat par une nouvelle étude des restes humains et, en particulier, de leurs structures osseuses et dentaires internes. Leur analyse exhaustive permettra de lister les caractères dérivés modernes présents, de définir leur stade évolutif et ainsi documenter l'histoire du peuplement humain d'Afrique du Nord. Ceci est tout à fait innovant dans la mesure où de telles analyses n'ont pas encore été menées dans le cadre d'une approche intégrée, couplée à une re-contextualisation géologique et géo-chronostratigraphique des vestiges humains, menée dans le cadre du programme (n°24520 CNRS-CNRST) et qui seront utilement intégrés dans ce but.

Ce programme, porté par deux membres scientifiques de la mission archéologique El Harhoura-Témara, vient donc en complément des tâches 2 et 4 (figure 1) du programme quadriennal. Il permettra notamment d'intégrer les vestiges humains paléolithiques découverts à El Harhoura 2 et El Mnasra à l'étude phylétique et du peuplement humain ancien dans la région de Rabat-Témara.

### **5.4. Programme COLOR-HOM, Idex SUPER (2014-2015)**

*Resp. : R. Nespoulet, MNHN, Département de Préhistoire, UMR 7194 du CNRS, Paris, France.*

Dans le cadre de l'appel à Projets 2014 Convergence@Sorbonne Universités « Sciences et Patrimoine culturel » de l'Idex Sorbonne Universités Pour l'Enseignement et la Recherche (SUPER), le projet intitulé COLOR-HOM (Des colorants et des hommes, 100 000 ans de modernité picturale) a été retenu pour un financement. Ce projet propose une approche interdisciplinaire et diachronique de l'utilisation des colorants au cours des 100 derniers millénaires au Maroc.

Dans le but de valoriser l'exceptionnel patrimoine archéologique marocain, il vise à mieux comprendre l'exploitation des ressources minérales par les populations historiques et préhistoriques en se focalisant sur le cas des pigments (oxydes de fer principalement). Ceci permettra de mettre en perspective les usages historiques des pigments et ceux du passé le plus lointain d'*Homo sapiens*.

**Les sources historiques** permettent de contextualiser les usages des colorants, comme ceux utilisés dans la fabrication des zelliges. On peut ainsi suivre l'évolution de cette technique depuis le X<sup>ème</sup> siècle jusqu'au présent. En remontant dans le passé, les sources documentaires se raréfient.

**Les sources archéologiques récentes** issues des fouilles complètent, puis remplacent les documents écrits. Celles menées sur des sites antiques fourniront le contexte de l'étude des colorants.

**Les sources archéologiques anciennes** montrent que les sociétés sans écriture (Néolithique et Paléolithique) ont utilisées des colorants. Pour les oxydes de fer travaillés découverts dans la région de Témara dans des niveaux datés de 100 ka, aux origines de l'Homme moderne, la question se pose de leur(s) usage(s). Il est également prévu d'analyser des oxydes de fer associés à des industries acheuléennes, dans le sud du Maroc, afin de voir s'ils ont été utilisés ou s'ils sont « naturels ». Ces approches s'inscrivent dans un même territoire. Ceci permettra de croiser les données et les interprétations par des approches transversales. Les mêmes ressources naturelles ont-elles été

utilisées au cours du temps ? Comment interpréter l'évolution des besoins et des utilisations des colorants ? En comparant les pigments naturels à ceux utilisés en contexte archéologique, il sera possible de reconstituer les sources d'approvisionnement et les circulations des matériaux dans des territoires.

Concernant la fonction des pigments, en partant des périodes historiques, nous remonterons jusqu'aux sociétés préhistoriques où seules les analyses géochimiques et fonctionnelles permettront de proposer des hypothèses. En particulier les usages domestiques *versus* les usages esthétiques et/ou symboliques.

#### **5.6. HELART : Programme national de développement de la recherche en Sciences humaines et sociales (DEV-SHS) CNRST (2011-2014)**

##### **Thème Patrimoine culturel : gestion, conservation, réhabilitation et valorisation économique**

*Responsable : Mohamed Abdeljalil El Hajraoui, Institut National des Sciences de l'Archéologie et du Patrimoine.*

Ce programme intitulé « Hommes et environnements sur le littoral atlantique de Rabat-Témara depuis 100 000 ans » (HELART) a pour but d'aborder les questions relatives à l'origine de l'Homme moderne et de ses comportements dans la région de Témara, en se basant sur les résultats obtenus lors des fouilles de ces dernières années, qui apportent de nombreuses données. Les vestiges humains associés à la culture atérienne découverts dans cette région sont les seuls actuellement connus pour l'ensemble du Maghreb. Associés aux autres découvertes archéologiques et paléontologiques, la région de Rabat-Témara offre ainsi un cadre exceptionnel pour étudier, à une échelle régionale, l'émergence et le développement de l'Homo sapiens, ainsi que l'apparition des comportements dits modernes. Le choix d'un travail interdisciplinaire en lien direct avec plusieurs équipes internationales (Maroc, France, États-Unis), qui travaillent avec des approches et des concepts parfois divergents permettra d'enrichir le débat scientifique et fera émerger de nouvelles problématiques concernant l'étude de l'Homme fossile au Maroc.

#### **5.7. Erasmus Mundus granting for Moroccan teachers**

In the frame of Erasmus Mundus, 3 Profs submitted dossiers to Erasmus Mundus and obtained grants for coming to Paris and Ferrare. They participated to teaching to Modules and also to the training of some PhD students.

#### **5.8. CNRS-CNRST PICS : Datation et caractérisation de matériaux archéologiques et géologiques pléistocènes marocains.**

*Responsables : Mustapaha Haddad, UMI, Christophe Falguères, MNHN*

The scientific collaboration between Paris and Meknes plans to enhance the knowledge and the expertise of both laboratories. On one side, Meknes brings an experience on the signal analyse and all characterization methods applied on archaeo and geomaterials. On the other hand, Paris is specialized into Dating methods. Leaning on a moroccan-french project of excavation effective since more than 10 years at Rabat-Temara prehistoric sites, our project follows its way trying to settle a dating lab at Meknes. Both labs already performed dating projects on different types of samples using ESR and U-series methods. When these results will be compared with those obtained with characterization methods such as FTIR, XRD, Raman), our knowledge on prehistoric and geologic sites in Morocco will be improved.