

MOBILITHICS: Fingerprinting the exploitation of lithic resources among *Homo sapiens* and the last *Homo neanderthalensis*

María Soto^{1,2}, Juan Ignacio Morales^{3,4,5}, Hassan Aouraghe⁶, María Gema Chacón^{3,4,7}, Robert Sala-Ramos^{3,4}

¹ Madrid Institute for Advanced Study. Casa Velázquez. C/ de Paul Guinard, 3 28040 Madrid, Spain.

² Departamento de Prehistoria y Arqueología. Facultad de Filosofía y Letras. Universidad Autónoma de Madrid. Campus de Cantoblanco, 28049 Madrid, Spain, marial.soto@uam.es

³ Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain.

⁴ Àrea de Prehistòria, Universitat Rovira i Virgili (URV), Tarragona, Spain, jmorales@iphes.cat, gchacon@iphes.cat, rsala@iphes.cat

⁵ SERP, Departament d'Història i Arqueologia, Universitat de Barcelona, Spain

⁶ Université Mohammed Premier, Faculté des Sciences, Département de Géologie, Oujda, Morocco. aouraghe.oujda@gmail.com

⁷ Histoire Naturelle de l'Homme Préhistorique (HNHP), Muséum national d'Histoire naturelle, UMR7194, 1 Rue RenéPanhard, 75013, & Musée de l'Homme, 17 Place du Trocadero, 75016 Paris, France

Abstract – Mobilithics is a multiscale project aimed at characterizing the lithic resources exploitation and territorial adaptive responses among the last neanderthals and *Homo sapiens* to different climatic, cultural, and biological dynamics. The project focuses on the Middle-to-Later Stone Age, in North Africa, and the Middle to Upper Palaeolithic Transition in the Mediterranean basin of the Iberian Peninsula, as key scenarios for the origin and expansion of our species. Results on geospatial modelling, petrographic and geochemical analysis, and multivariate statistics and predictive models determine the variability on resource procurement and territorial structure. These will contribute to the international debate on the adaptability of our species to different palaeoenvironments, sociocultural realities, and changing climatic conditions.

I. INTRODUCTION

Mobilithics is aimed at characterizing the adaptive responses among *Homo sapiens* during its origin in Africa and their later expansion through Eurasia. This project will provide high-resolution data through the investigation in two key scenarios for the development of our species, the Middle Stone Age - Later Stone Age Transition in Eaststern Morocco, and the

Middle to Upper Palaeolithic Transition in the Mediterranean area of the Iberian Peninsula. Geo-spatial, mineralogical, and geo-chemical data on the exploited resources will help to determine the variability patterns of the palaeoeconomic behaviours and territorial boundaries, as tangible adaptive responses to changing environments on a global scale. The behavioural flexibility of our species allowed its adaptation to new climatic conditions, and its expansion to diverse ecological niches. Archaeologically, these adaptations are visible in the increase of complexity and in the ramifications of economic strategies during the Upper Pleistocene (120-12 ka BP).

Research challenges in understanding the expansion pattern of *Homo sapiens* comes from the demographic profiles and the potential interactions with other human species, such as *Homo neanderthalensis*. Overcoming these challenges requires integrating novel points of view, the combination of different disciplines, and to pose innovative paradigms and alternative hypotheses to offer new data to traditional debates [1]. This project focuses on procurement strategies and management of lithic resources, as archaeometric keys in human adaptation to new territories, climatic regions, and cultural scenarios during the Upper Pleistocene. Mobilithics proposes a geo-spatial study on the location, distribution, and abundance of abiotic resources in different territories, and the application of petrological and geo-chemical

techniques to characterize the regional availability and exploited lithologies in the archaeological assemblages [2,3].

II. STUDY AREAS

MobiLithics is based in two significant geographic areas (Fig. 1) for the study of the origin and dispersal of *Homo sapiens*, North Africa and the Iberian Peninsula, respectively.

North Africa preserves a complete evolutionary record of *Homo sapiens*, from its origin at the Middle Stone Age to the Later Stone Age and Holocene. Our species thrive in a changing climatic scenario, characterized by the succession of moderate and hyper-arid phases linked to the cyclic expansion of the Sahara.

The Iberian Peninsula, on the other hand, represents the territory where the *Homo sapiens* expansion culminates in Europe, and where the last interactions with Neanderthals took place.

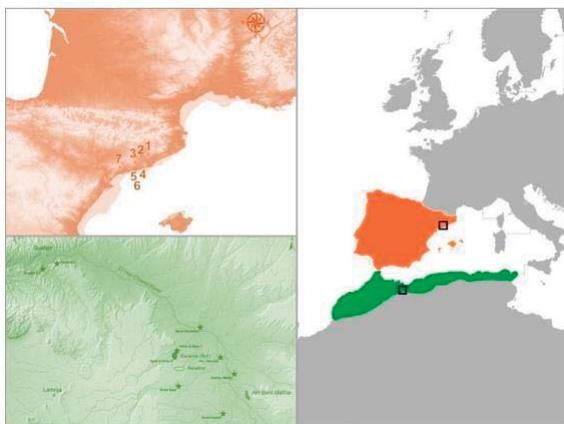


Fig. 1. Representation of the study areas of Mobilithics

III. STATE-OF-THE-ART

The Upper Pleistocene in North Africa is characterized by strong climatic fluctuations that caused unstable conditions for habitability. However, it constitutes an interesting territory for human evolution, as it is considered one of the main emergence foci of *Homo sapiens*. The earliest remains associated to *Homo sapiens*, dating ca. 300 ka BP, have been described in Morocco [4].

This area has been recurrently occupied since the MIS5 (123 ka BP), coinciding with climatic ameliorations, associated to the ‘Green Sahara’ model, causing an increase in precipitation and the expansion of the savannah and wooded grasslands. These improvements were followed by a series of regionally unstable periods (70-30 ka BP) until the arrival of arid conditions (ca. 20 ka BP), and by later climatic improvements until the Holocene.

During this unstable period a relevant, heterogeneous, and asynchronous techno-cultural transition occurred, the Middle-to-Later Stone Age (MSA-LSA), characterized by the technological substitution of flake-dominated assemblages for the bladelet-dominated ones. Regionally,

the LSA is defined by the disappearance of the Atero-Mousterian tradition (MSA) and its substitution by the Iberomafrican complexes. The Atero-Mousterian includes: the Aterian, characterized by Levallois sequences, tanged tools, bifacial foliates and blade production; and the Mousterian, also a Levallois tradition but without tangled elements [5]. Sites, such as Contrabandiers or Grotte de Rafhas, show Aterian-Mousterian superposition. However, recent evidence from Ifri N’Ammar and Wadi Gran, tend to show the alternance or even the reversal of this sequence, confirming the need of novel paradigms to traditional approaches.

Traditionally, techno-typological monotony and scarce variability on site functionality have been suggested for the MSA. However, during its final phase a change in the settlement patterns is detected; the number of sites increase exponentially and are systematically associated to the immediate areas of fluvial deposits. Except for the Dabban assemblages from the Cyrenaica [6], the Moroccan Iberomafrican represents the earliest LSA appearance in North Africa (25-23 ka BP) and seems to represent a migratory flow, propitiated by the Sahara contraction and the interconnection among different regions [7,8].

Besides the technological changes, during the Later Stone Age an increase of gathering strategies and vegetable processing, the origin of necropolis as funerary practices or the generalization of dental avulsion are documented, according to sites such as Ghar Cahal, Hattab II, Kefh el Hammar, Tatoralt, Ifriel Baroud, Ifri N’Ammar o Tamar Hat.

The second phase of this project is focused on the Mediterranean Iberian Peninsula during the Late Middle Palaeolithic and the Early Upper Palaeolithic (43-35 ka BP), a key period regarding evolutionary biology and culture, because of the disappearance of *Homo neanderthalensis* and its substitution by *Homo sapiens* populations [9]. This transition occurred through the climatic oscillations of Marine Isotopic Stage (MIS) 3 (57 – 29 ka BP), and climate-derived conditions have been proposed as ruling factors for the biological substitution.

The cultural sequence in the SW of Europe is structured by the succession of Late Middle Palaeolithic assemblages, known as Transitional Complexes as the Chatelperronian, associated to *Homo neanderthalensis*, and the Proto- Aurignacian and the Early Aurignacian, linked to *Homo sapiens*.

The Iberian Peninsula is a territory of special interest as it represents the southernmost and latest area for the *Homo sapiens* expansion and consolidation in Europe. Based on the available data, the arrival of our species to the Iberian Peninsula occurred synchronically to the rest of Western Europe. However, this arrival seems to be limited to the northern area of the Cantabric area and the Pyrenees [10], documenting the succession among the Late Middle Palaeolithic, Chatelperronian, Proto-Aurignacian and Aurignacian. According to actual data, the total occupation of the peninsula by *Homo sapiens* was the delayed for ca. five millenials. During this lapse, Neanderthals continued occupying the territory [11]. Some proposals claim that *Homo sapiens*, adapted

to the steppe-like environments with abundant biomass, did not adapt to the desert-stepped and arid conditions of Central Iberia [12,13].

This scenario however clash with the global rapid expansion of Modern Humans and their ability to adapt and prosper in challenging environments [14].

Determining the differences between the palaeoeconomic behaviours of both species will offer new insights to the adaptative economic and subsistencialstrategies during their coexistence

IV. MATERIALS AND METHODS

The first phase of this project will be focused on the Ain Beni Mathar - Guefaït basin, in Eastern Morocco, where several stratified open-air sites, such as Sabh el Ghar or Tahya 3 yielding abundant stone tools, faunal remains and extremely well-preserved hearths have been discovered during several fieldwork seasons within a bilateral Spanish-Moroccan archaeological project developed since 2006 [15] (Fig. 2).

The area is characterized by a high abundance of different lithologies prone to be knapped such as rhyolithe, basalts, sandstones, limestones, dolerites and cherts.

The geo- spatial and chemical characterization of the lithic resources available in the territory and the different archaeological assemblages will determine: i) the procurement strategies and exploitation territories during the MSA; ii) the continuity or rupture traits on those dynamics during the LSA; and iii) the correlation among the observed adaptive responses and the regional climatic cycles, which are being analyzed through a multi-proxy approach including geochronology (magnetostratigraphy, ESR, TL, OSL U-TH, Cosmogenics and C14), palynology, phytoliths, anthracology, paleontology of macro and microvertebrates, and isotopic analysis on plant wax biomarkers, faunal remains and pedogenic carbonates [12].

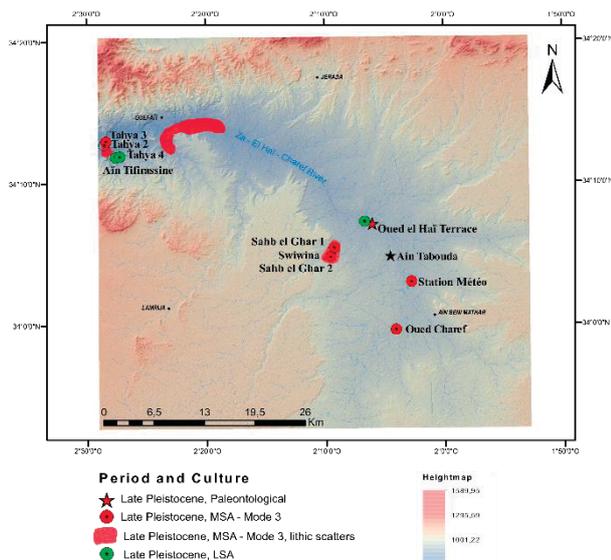


Fig. 2. Detailed map of the MSA-LSA sites located in the Ain Beni Mathar- Guefaït basin (Eastern Morocco)

MobiLithics proposes a multiscale analysis to locate and characterize the exploited lithic resources. These analysis include: 1) systematic geoarchaeological surveys and sampling; 2) creation of thematic cartography and 156 bilateral regional reference collections based on the

principles of Open Science Framework to ensure the accessibility of raw data, guaranteeing the accomplishment of FAIR principles, through the creation of certified repositories and pre-prints to ensure the data interoperability; 3) determination of availability indexes through geospatial statistics through the ArcGIS Spatial Analysis Extension Tools such as Kernel density and Path Distance and Probabilistic Models of Resource Distribution as Empirical Bayesian Krigging and interpolation simulation, and the Spatial Statistic Tools such as Generalized Least Squares and Geographic Weighted Regression; 4) macroscopic, mineralogical and geochemical analysis, through thin sections, Raman Spectroscopy, Energy Dispersive X-Ray Spectroscopy and Energy Dispersive X-Ray Fluorescence; and 5) Statistical treatment of data using multivariate analysis (PCA, FA and Clusters), discriminant analysis and Predictive Models to determine the procurement patterns and territorial extents.

The territorial models of adaptation to changing climatic conditions during the Upper Pleistocene in North Africa will serve as a comparative framework to understand the expected models for the Middle to Upper Palaeolithic Transition in Europe [16].

New investigations in the Mediterranean area of Spain have revised the traditional geographic-chronological scenario discovering novel sequences [17, 18], such as Cova Foradada, Griera, Cova Gran and Mas del Trader. These archaeological sites preserve several stratified occupations associated to the Middle to Upper Palaeolithic Transition phases, including for the first time Chatelperronian evidence far away from the Cantabric and Pyrenees areas (Fig.3).

The area is geologically limited by the Catalan Prelittoral Range and the Ebro basin, and characterized by Triassic [19], Lutetian and Bartonian aged formations yielding abundant silicifications [20], exploited as lithic raw materials since the Early Pleistocene

MobiLithics plans the application of the designed multiscale protocol to these sequences to determine if variation between territory exploitation strategies existed between *Homo neanderthalensis* and *Homo sapiens*, and what is the evidence of adaptation to new environments among the latter species.

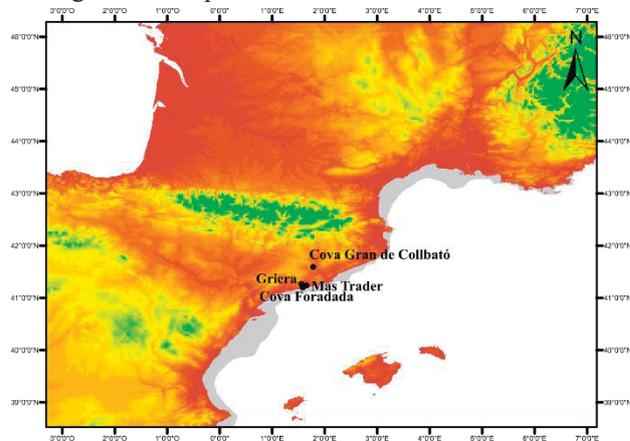


Fig. 3. Detailed map of MobiLithics archaeological sites showing the Middle to Upper Paleolithic Transition in NE Iberia

V. DISCUSSION

The role played by resource distribution, procurement strategies, mobility, and site functionality on the adaptation to new territories, will provide data for the

expansion process of our species in the peninsula.

A progressive diversification of exploited resources, increase of long-distance incomes, and the expeditization on local resource management should be expected as result of stabilization and increase of residential settlements among highly mobile groups.

These proxies will determine discontinuities and differences in the settlement patterns between the Middle Stone Age-Later Stone Age and the Middle to Upper Palaeolithic Transition, evidencing the adaptive mechanisms of the first representatives of our species.

Definition of the raw materials sources and procurement strategies will provide us with novel quantitative insights for describe foraging (daily displacement between the source areas and procurement source) or logistical procurement strategies (based on specific displacements needing more than one night to return to base camps) and allow us to define the territorial mobility in the study areas [21, 22].

To determine the patterns of continuity or discontinuity in the palaeoeconomic behaviours will define the scope of variability and flexibility in the subsistence strategies of *Homo sapiens*, determining whether these are explicit causes for the success and rapid expansion of our species, and contributing to the actual debate around their migratory flow, the interaction with other species, and the regional adaptive reactions to global environmental and climatic changes.

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