Connecting Data. GIS and the Human History of the Oukaïmeden Valley

Ensamblando datos. SIG y la historia humana del Valle de Oukaïmeden

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Abstract

Geographic Information Systems have become recently a methodological device to analyze the social configuration of historical landscapes. This paper deals with mobility and visibility as basic agents of the landscape organization, which is in turn, one of the theoretical bases of ARPA's project. Hence, the need of applying these methodological tools to achieve a deeper knowledge of that process. GIS techniques show a direct connection between rock art or tumuli and the most efficient lines of movement, the best visibility orientations or the wet areas. Following Annales' idea of Longue Durée, this paper traces the human process of modelling the Oukaïmeden landscape, from prehistoric times to more recent, historical ones, in which the control of critical resources and of mobility played a key role.

Key words: *Landscape Archaeology, Geographic Information Systems, mobility, visibility, NDVI, MADO, tumuli, rock art.*

Resumen

Los sistemas de información geográfica han sido utilizados en los últimos años como herramienta metodológica a la hora de analizar la configuración social de los paisajes prehistóricos. En nuestro trabajo, y como una de las líneas teóricas de nuestro proyecto, entendemos la importancia de factores como la movilidad o la visibilidad dentro de esta configuración del paisaje. De ahí, la necesidad del uso de este tipo de herramientas metodológicas para comprender de una manera más profunda dicho proceso. La aplicación de los sistemas de información geográfica a la hora de analizar el arte rupestre y otra serie de elementos materiales prehistóricos, como los túmulos, parecen mostrarnos una relación directa entre dichas evidencias y factores tales como las líneas de movimiento, los condicionantes de visibilidad o las zonas de acumulación de pastos. De esta manera, y siguiendo la idea de la Longue Durée, hemos analizado la configuración del paisaje del Valle de Oukaïmeden desde épocas prehistóricas hasta momentos más recientes, pudiendo entender como el control de los recursos y la movilidad, han sido factores determinantes en dicho proceso.

Palabras clave: *Arqueología del Paisaje, Sistemas de Información Geográfica, movilidad, visibilidad, ndvi, MADO, túmulos, arte rupestre*.

Introduction

The organization of space is one of the ways in which a society embodies its way of being in the world and sets up its landscape. In other words, the landscape is a social product, and through the analysis of the different aspects that shape it, we can approach to the past societies' mind and perception, which lies behind it (Criado & Mañana 2003:103).

From this view, we understand the setting of a new space as a social construction of the world around (Hernando, 2002), an as embodiment of the new ideological selected discourse (Foucault, 2008:14). Landscape is a cultural construction and as Berque explains, the word *landscape* it is neither universal nor the idea of a *landscape* does exist in every language (1997 and Berque *et al* 1997). In our view the concept of a landscape emerges at the end of a lengthy process of mental and physical taming of Nature. In that way it is not by accident that as Berque explains (1997), the word *landscape* is used first in the fifteenth century AD in the Tuscan cities and in Flanders. In both cases we think that it would be the result of a process of fighting physically, but also and specially mentally, against the Nature, after the Fall of the Roman Empire, which brought a population decrease and an advance of the dense forest in temperate Europe (Fumagalli 1989 and 1994) and also of combating against the sea by means of the polders in the case of the lowlands of Flanders and Holland. So, the idea of a landscape doesn't exist for those, as hunter-gatherers, who do not differentiate among Nature and Culture, as they consider themselves to be part of the Nature (Bird-David (1990). On the contrary, when the process of detachment of Nature concludes, human beings acquire perspective enough to perceive and conceptualize it as landscape. That could explain the philosophical meaning of the word *landscape* in Chinese language, or Claude Cézanne's claim quoted by Berque (1997:8) that: "Farmers living in Mount St. Victory do not see the mountain" since landscape is a cultural but especially a perceptual concept (Merleau-Ponty 1975).

After Tilley (1994), the conceptualization of a landscape is connected to specific experiences, either personal, or social. Without bearing it in mind it would be difficult to understand the meaning of every landscape. These experiences inscribed in the landscape, help humans to create a new sense of place, they persist over time and help to keep memory (Bradley, 2000:158). Therefore we need to analyze the archaeological manifestations that, as Ingold (1993) explains, shape the landscape layers, made of time and human experience, in order to understand the meaning of the Oukaïmeden's landscape. In the present case these manifestations are rock art, dwellings and tumuli.

Goals

We aim to explore the different ways of human occupation of the valley through the systematic use of GIS technologies. Together with the different patterns of occupation of space we have also tried to analyze the variety of models of mobility along the valley and its possible relation with rock art and the funerary record.

The settlement record, as seen above is very ephemeral and unfortunately quantitatively, less representative, therefore it has not been included.

First step has been the determination of the main wandering areas of the valley, to see how they are related to the main rock art stations.

A key element for analysis was the possible connection between rock art and wet and pasturage areas, not simply because these are always a critical resource for pastoralists. Our hypothesis is that the beginning of the valley frequentation was caused by a worsening of climatic conditions, which led to its regular exploitation and also to claiming rights on high mountain resources by some groups of prehistoric pastoralists. Therefore, the relationship between the grazing areas and the rock art depictions is paramount to explain the historical dynamics of Oukaïmeden Valley.

1. Methodology

1. 1. *Cartographical base Digital Elevation Model*

As already said, one of the main component in the ARPA's project approach, was to get a cartography from which, relevant information for our analysis could be extracted. The acquisition and processing of proper cartography has represented a major challenge for the project due to the lack of quality mapping in the area. The only available maps had scales of 1:100.000 and 1:50.000 and had been produced in 1993 and 1968 respectively, and thematic maps - land use, geology, i.e. - were inexistent. This situation represented a severe handicap, as the landscape analysis required altimetry data to build the Digital Elevation Model (DEM) in order to relate variables as topography, mobility and main visibility conditions. The alternatives were either scanning the existing maps or to acquire digital images online. Online images were restricted to NASA and ASTER global digital elevation models (GDEM) and maps,

and the second one was chosen over classical topographic mapping.

All ASTER DEM data are referred to WGS84 reference system and the spacing is 30 m pixels (1 arcsec if longitude and latitude) and the altitudes are the result of the combination of the ellipsoidal heights with geodic model EGM96.

Digital elevation models contain two types of information, one explicit, as the altitude, and other implicit, regarding the spatial relationships between data. Both types of information are complementary and allow getting results on land morphology in a comprehensive and objective manner.

The description of the relief from a DEM is done by obtaining a set of measures that define geometric terrain features at different scales. This process is known as parameterization relief and the variables included are gradient, slope and orientation/ aspect. Other important variables related to the study area were obtained by the same way: as watersheds, flowlines (hydrological network), viewsheds, intervisibility between points, topographic profiles, as well as the determination of friction surfaces to create optimal pathways.

Satellite images

Satellite imagery has played a key role in the present project, firstly acting as a base map of the area which could be photo interpreted, secondly as a first step to generate the nonexistent land use mapping, and finally to carry on several analyses related to the ground surface. To use images discriminating the different ranges of the electromagnetic spectrum and a high spatial resolution, a cover analysis and classification was required. In our case and without high spatial resolution images available, we had to make use of the Thematic Mapper (TM) sensors. We have worked with the image Ikonos 1 m / px (IK), dated to 15-12-2000, 26-01-2000, 05/04/2002, (4 bands RGBNIR).

As for the images period, we sought to use those that covered the seasons within which the pastoral use of the valley takes place and also when there is not snow and the traditional paths are walkable, i.e. between late spring/summer and early fall (from May to October).

The selection of bands for every image was aimed to discriminate ground cover, water points and types of soil. This is due to the fact that within the wide sweep done by the TM radiometric spectrum sensor, the visible and the near and middle infrared bands are those where the vegetation has more reflectivity.

Thematic mapping by remote sensing

The mapping through satellite images is an alternative way to produce specific land use maps, and a helpful method when this kind of maps are unavailable, or the scale is too small or not as reliable as required for these analyses. The extraction of the information on cover types detected by the satellite sensor was achieved through three different classifications: the Principal Components with the higher information content of every image, the bands generated after a Tasseled Cap transformation of every image and the NDVI vegetation index obtained independently for every image.

2. Analysis

Analysis of mobility in the Oukaïmeden Valley

Mobility analysis has been applied in GIS for years. These approaches vary (Llobera, 2000; Howey, 2007; Llobera et alii, 2011; Murrieta, 2012). They all agree that human movement is determined by physical factors as cost and friction, this last understood as the difficulty offered by the terrain to move through it. Cost, on the other hand, refers to the effort needed to move between two points given the friction of the surface and the distance. In the present case, slope and water streams are the variables used as factors determining friction and cost in the movement through the Oukaïmeden Valley. On the other hand, being Oukaïmeden an embedded valley, crossed by streams and gullies, mountain passes and fords are variables that, together with the slope and water streams, should be borne in mind as determining and conditioning mobility.

Our main aim is to analyze how different archaeological entities, essentially rock art and tumuli are related with potential mobility areas, since in our view, this is a key factor to understand the way in which past occupants of the valley experienced, modelled and settled in the landscape. In that way the wandering through the valley would be critical for them, and their experience inscribed in rock art and burials, became landmarks.

We have chosen the Model of Optimal Accumulation Displacement from Origin (MADO) tool to analyze movement within the valley. MADO can be defined as a model of accumulative cost of movement from a given point of departure, but without a specific point of destination (Fábrega, 2006:9). In this kind of analysis, an image with a ranking of values is generated, where the higher ones indicate areas of potential movement. The next step is the

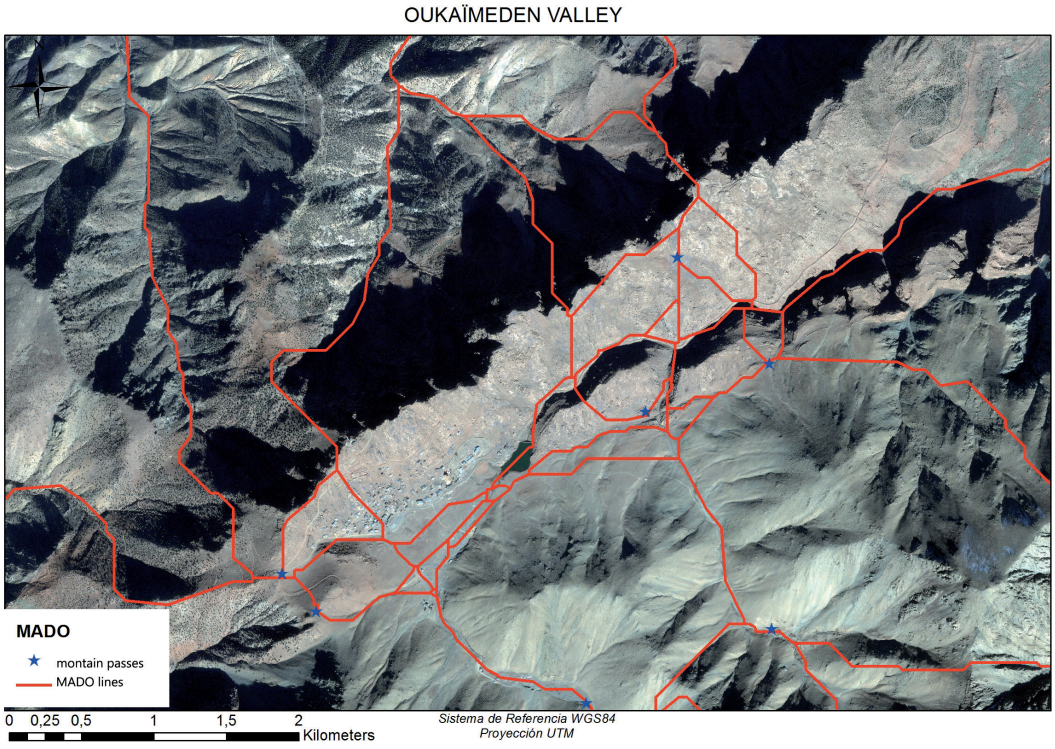

Fig. 1. MADO from all mountain passes of the Oukaïmeden Valley.

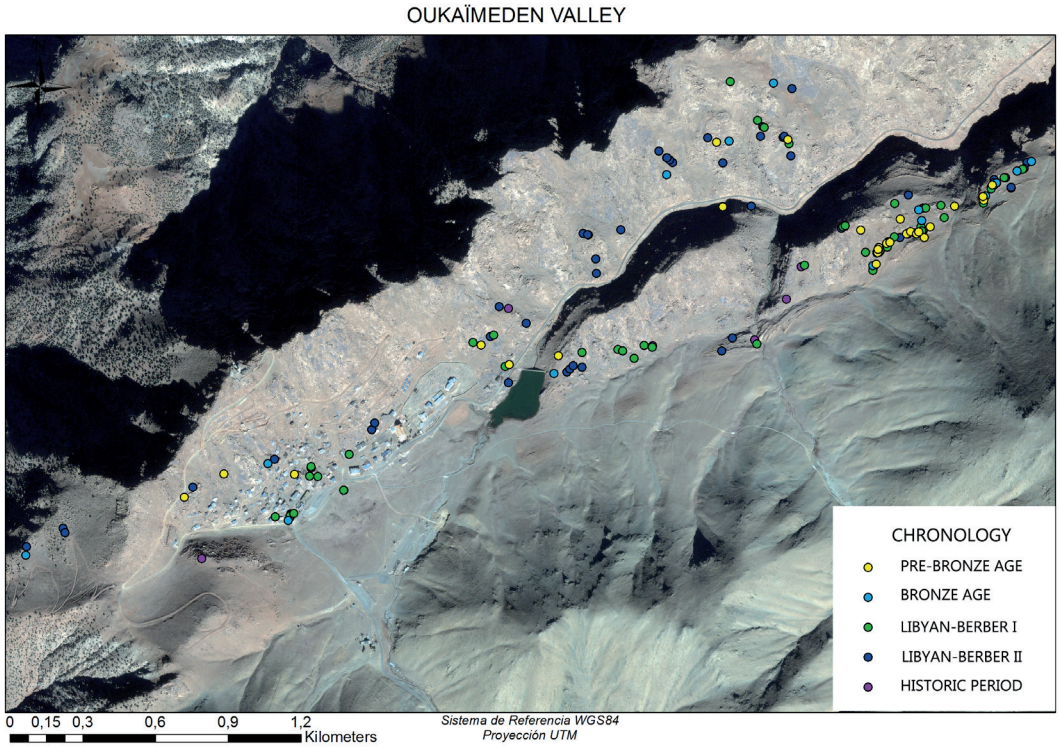

Fig. 2. Rock art ordered by chronology.

	PRE-BRONZE	BRONZE	LIBYAN-BERBER I	LIBYAN-BERBER II	HISTORICAL
maximum	262,3595517	262,3595517	292,765143	334,660096	317,9268643
minimum	2,35275844	2,35275844	0,2122173	2,24724156	10,20129657
average	86,05687851	95,55668761	93,28671147	108,2209814	106,8619082
Standard Dev.	54,4582198	65,60548304	66,18662092	74,95200061	74,77963198

Table 1. Distances between MADO lines and rock art chronologically classified.

reclassification of the image to select the highest values that represent these possible routes, which are represented as lines, known as "MADO lines." The reclassification has been performed using the parameters set by the Standard Deviation.

In our analysis, we have established individually, a MADO from every ford and mountain pass, seven in total, using variables such as friction, slopes and water courses, and applying the Tobler's algorithm (1993). The result is a lines accumulation network, of potential movement from these established points, without a predetermined destination (fig.1).

Once established with MADO the main lines of mobility, an analysis of proximity between the different entities and the different layers of analysis has been carried out. The direct relation by neighbourhood may indicate a direct or symbolic control over a resource, which may vary depending on the historical context of every case study. The variability of styles and chronology, can lead to a lot of huge and sparse data, despite this, some trends within the different classifications can be seen.

In the case of rock art, we have sorted the different entities by chronology and typology. In the first case we have distinguished according to statistics (See above Chapter 5.2), five periods: Pre-Bronze (Late Neolithic/Copper Age), Bronze Age, Libyan-Berber I, Libyan-Berber II and Historical (fig 2). Concerning typologies, those more recurrent are animals, human depictions, weapons, signs, ethnographic designs and idols (fig. 3). The analysis of the MADO relationship with rock art classified

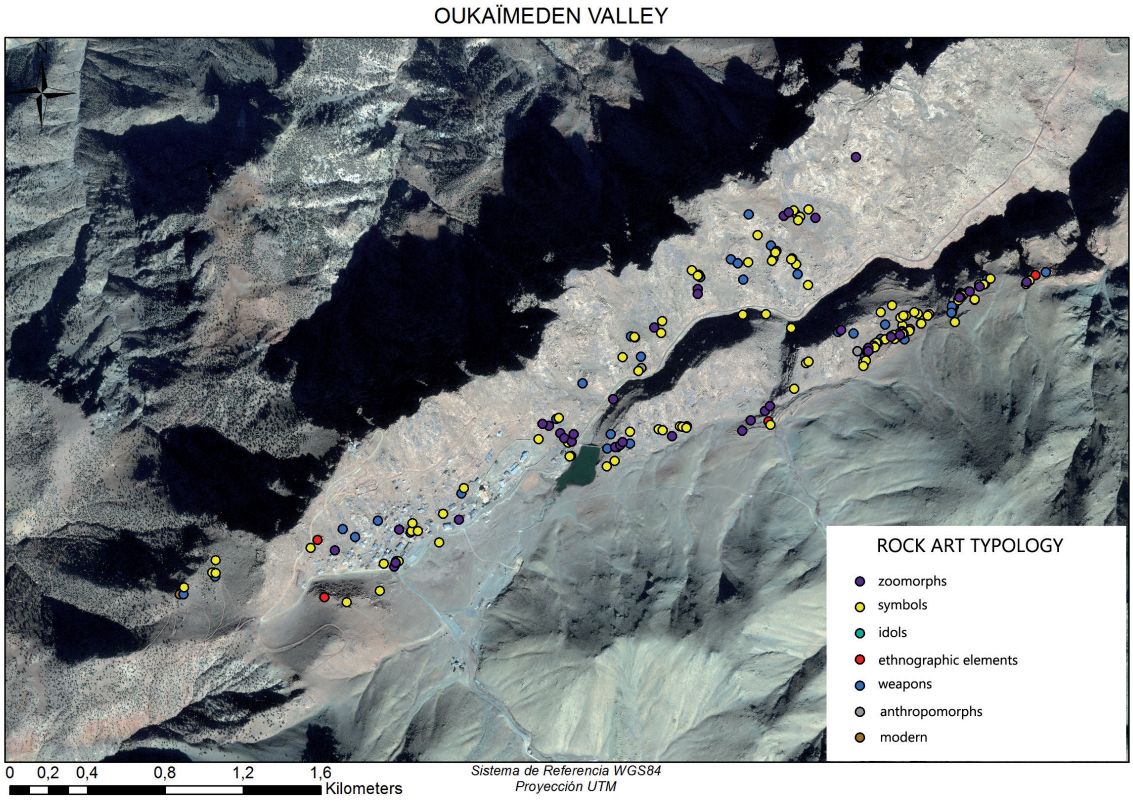

Figure 3. Rock Art ordered by types.

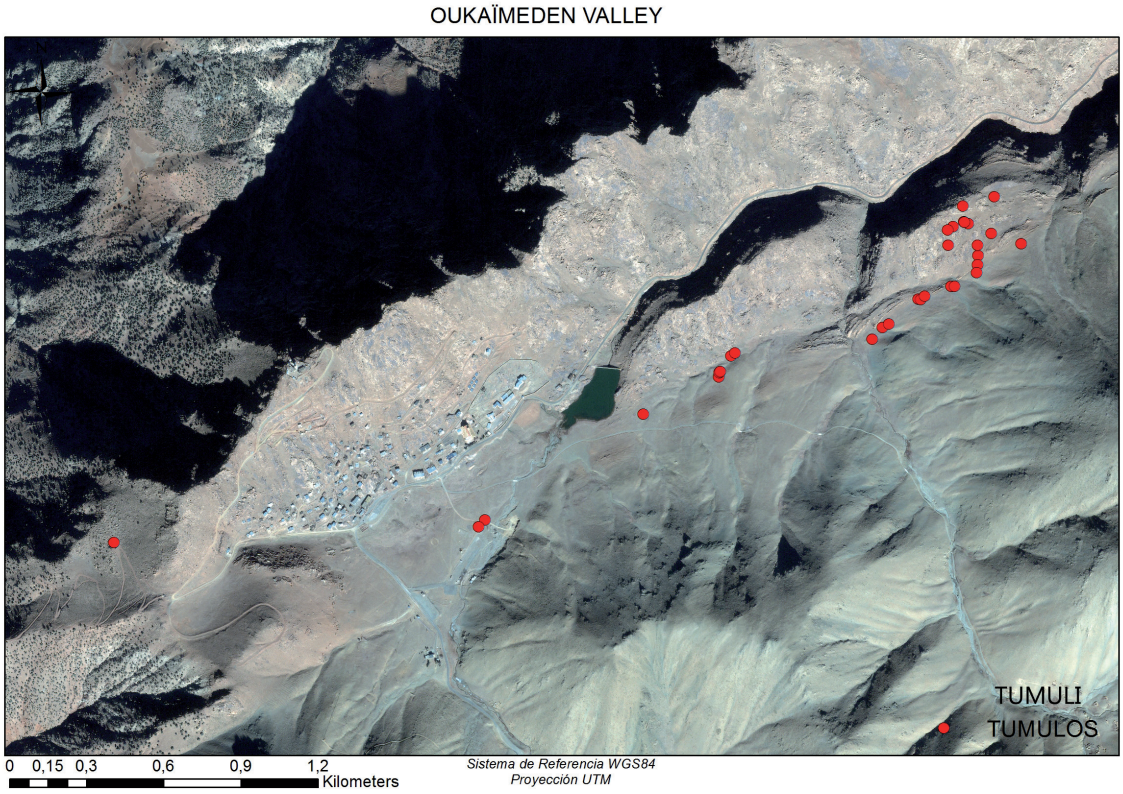

Fig. 4. Burial mounds.

by chronology, shows that Pre-Bronze carvings are the ones closer to the lines of motion. This may be explained as that the oldest engravings were located in areas more related with the movement of the first occupants within the valley. In other words, the movement would have determined the location of rock art but gradually, rock art would condition these people' movements.

Regarding typology, weapons, anthropomorphs and symbols present a very similar ratio of proximity with MADO's lines (around 92 meters), something understandable, as these kinds of depictions

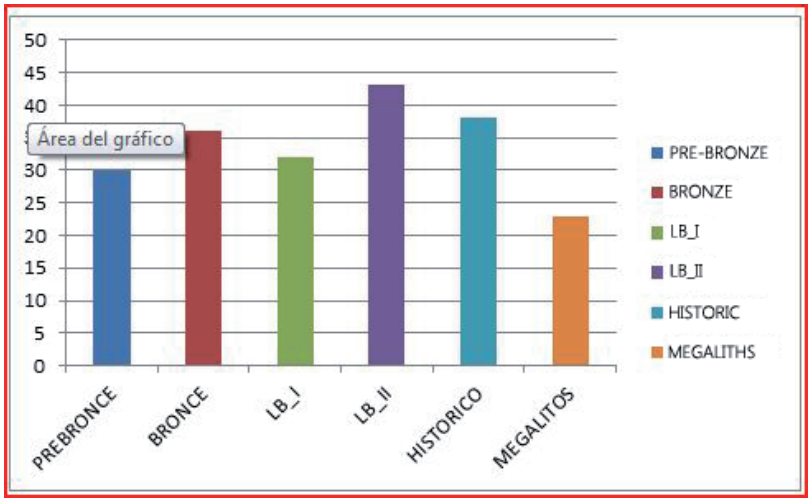

Fig. 5. Total percentage of visible areas classified by chronologies.

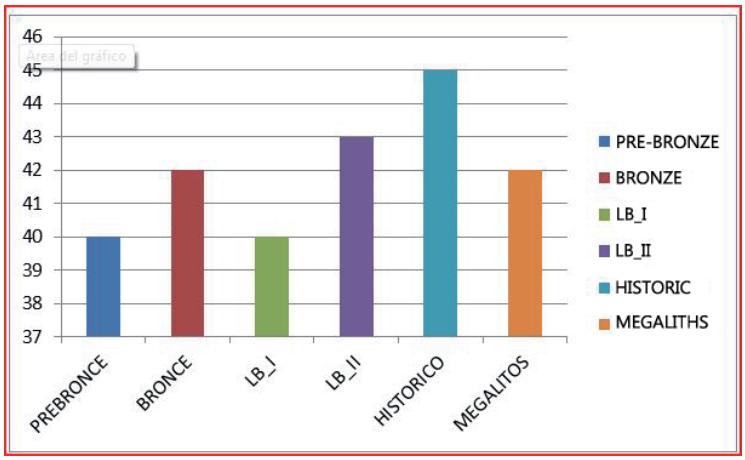

Fig. 6. Percentage of MADO's visual control from rock art stations.

often appear related. Zoomorphs, on the contrary, show a radically different ratio (around 130 meters). This is an interesting aspect, as most of these engravings are considered to belong to a Prehistoric period, while the remaining symbols are ascribed mainly to a Libyan-Berber Period. Regarding chronologies, it seems to be a progressive increase in the distances to MADO's lines from Prehistoric times to the Libyan-Berber ones, with a substantial change in the Bronze Age and another one within the Libyan-Berber II Period. (See tables 1 and 2).

A very significant fact is the relation between MADO lines and tumuli (fig. 4). If we compare them with the different rock art motives, it is outstanding their location, always on points where they exert a more direct control over the different routes of mobility generated from the MADO. So we could advance the hypothesis that tumuli were located in those areas which facilitated the control over resources of the valley considered critical and therefore, sanctioned by the ancestors.

Viewshed Analysis of the Oukaïmeden Valley

Viewshed analysis have been used throughout the last decades in Prehistoric Archaeology, and great developments, both at a methodological and at a theoretical level have taken place in them, (e.g. Llobera, 2005; Llobera, 2007), in which the different relations between perception and movement are seen as a key element.

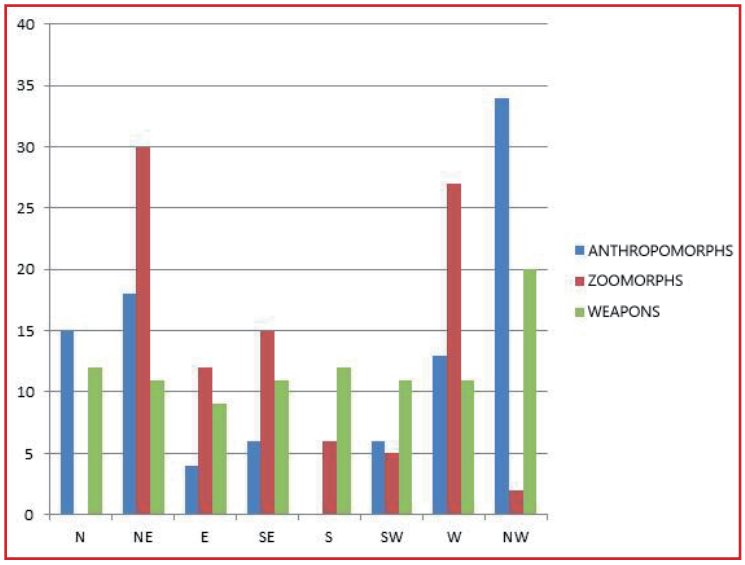

Fig. 7. Graphic of rock art orientation by categories.

The most common visibility analysis are the so-called "cumulative viewshed" (Wheatley, 1995) and "total viewshed" (Lee and Stucky, 1998). Even assuming some limitations – they do not consider the vegetation -, this kind of analysis allows exploring intervisibility between different archaeological entities. In the present case-study, we have conducted various visibility analysis based on the idea that the visual control and the visual connections are basic to understanding the perception that human groups had over their immediate environment. This idea was one of the main lines of research within the ARPA project.

To do this, various analyzes have been carried out considering different variables: chronology, panels' orientation and visibility from different routes (MADO). For these analyzes, we used the DEM Model produced as a cartographic base of the project. In the observation point we have calculated a 1.65 m. height, taking into account that it could have been the average height for people inhabiting the area. We have also added a vertical viewing angle of 130 °, which is the normal vertical angle of view of a human being.

When we analyze visibilities from the different rock art panels according to chronology, results may apparently be homogeneous. However, carvings belonging to the Libyan- Berber II period seem to stand out over the mean, in the different analysis undertaken in our project (fig. 5).

We can see in the graphic that the percentage of total visible area is higher during the Libyan-Berber II, being near 40%, although the average reaches around 30%. This could suggest a greater visual control of the territory during the Libyan Berber II.

The visual control of MADO is another important analysis. Its purpose is to observe the evolution of visual control on the main lines of wandering within the valley, which are the optimal routes of movement, as already shown elsewhere in this paper (see above).

Again, we can appreciate, that the visual control over the network of mobility increases during the Libyan Berber II period to a range of around 48% of the track, or, in linear meters, to 30,385m of a total of 62,540 meters of MADO (fig. 6).

Another viewshed analysis carried out, concerns the rock art panels orientation. In the case of Oukaïmeden, we have been able to decipher the orientation of most of the depictions. Despite being a fairly heterogeneous sample, we can see some uniformity in orientations, which point mainly northbound (NW and NE). (fig. 7).

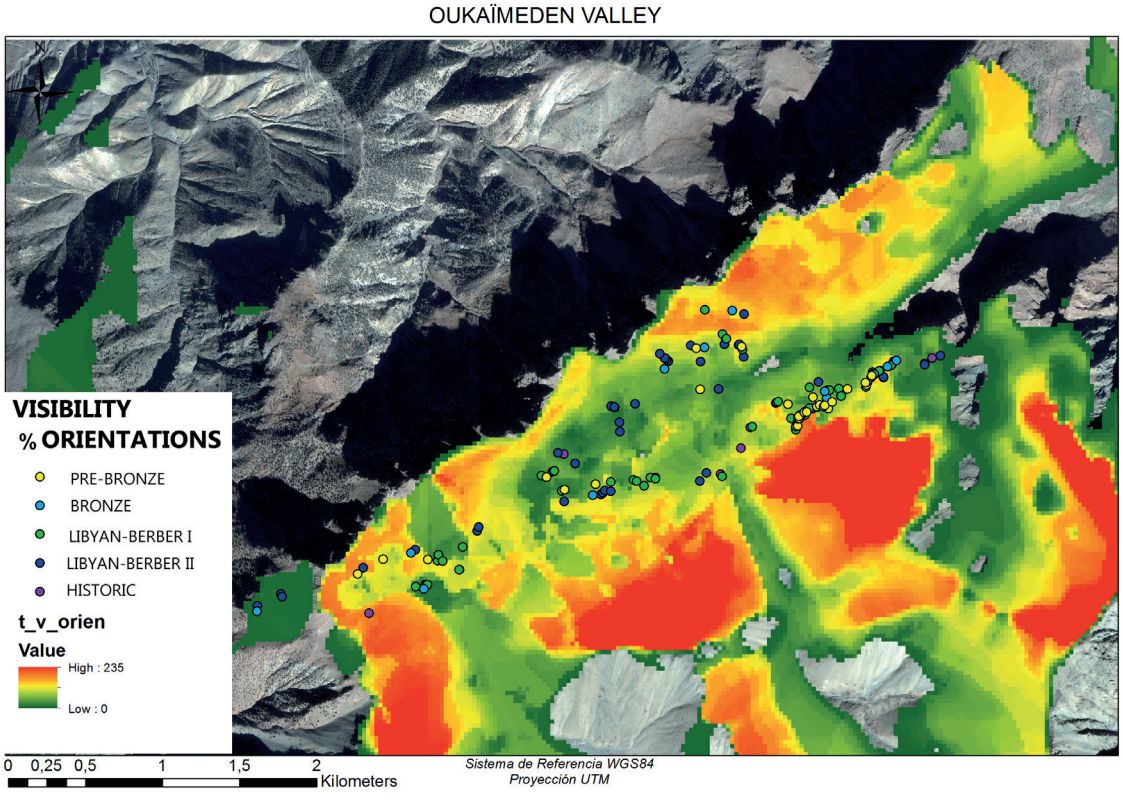

Fig. 8. Cumulative visibility of oriented rock panels.

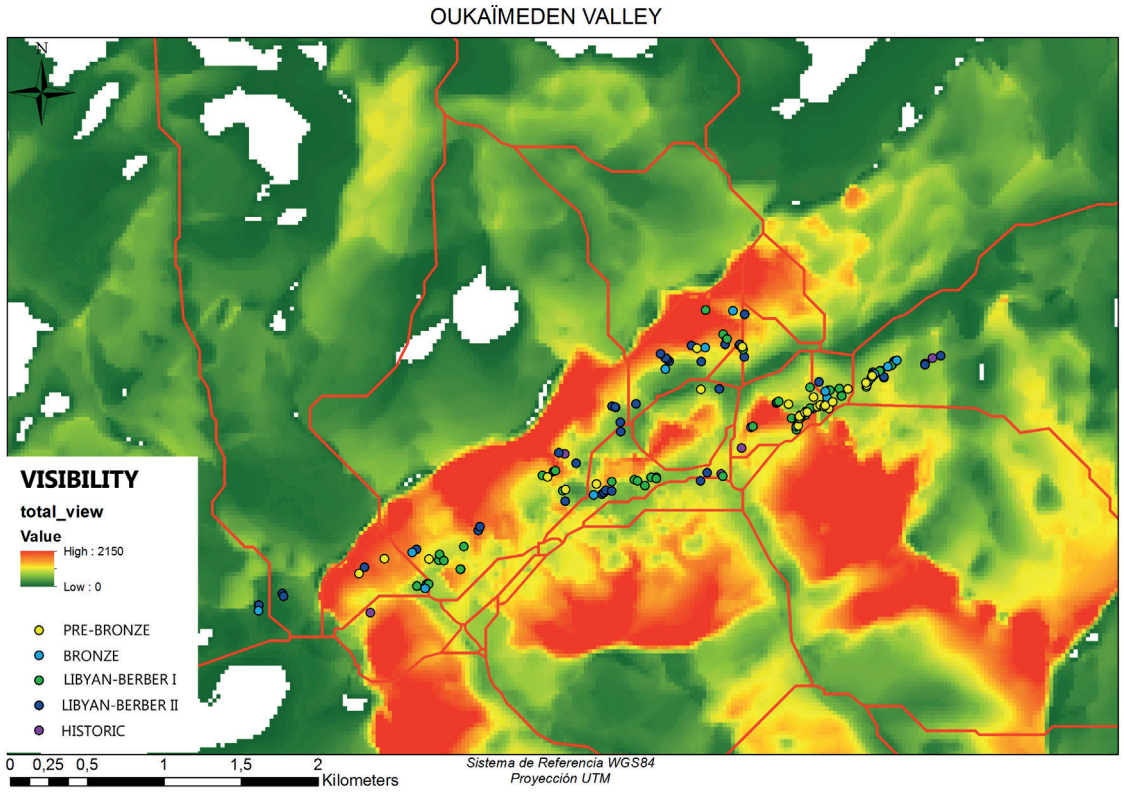

Fig. 9. Cumulative viewshed indices from MADO.

As the main dwelling areas seem to have been oriented to midday, it could be suggested that that rock art orientations are related to daily movements of shepherds and their flocks. The purpose of this analysis is to understand what someone could see from each panel when placed according to the carvings orientation. To perform this analysis, we have classified the depictions from its orientation (N, NE, E, SE, S, SW, W, NW). From there, several analysis have been performed, taking into consideration that the horizontal visual angle of a person is 180 °, and calculating an average height of the observer of 1.65 m.

Once added all visibility analysis performed, we can see in the map a tendency to a greater accumulation of visibility in the southeast of the valley, where stand the major mountain tops in the area. They are outstanding and could probably have been perceived as symbolic landmarks for locals (Fig 8).

As stated before (see above), the visual control of the environment seems to be a key element in shaping the individual and social identity of humans, regardless the chronological time we are talking about. Therefore in our view, it was essential undertaking, not only the analysis of the visual control of the different routes of mobility from the panels, but also the visual control of the panels from the different optimal routes of mobility. First step for it has been dividing our MADO lines into equidistant vertices every 10 meters, in order to conduct an analysis of visibility every 10 meters. This has produced a total of 6000 visibility maps, needed to see which ones are the zones with higher visibility indices within our study area (fig.9).

In figure 9 we can see which ones are the zones with higher visibility within the valley from the different lines of mobility. On the one hand MADO visibility from the rock art stations as much as MADO visibility of them, points that the degree of visibility was higher in Bronze Age than in the Pre-Bronze Period, it decreases a little again during Libyan-Berber I Period and gets higher in the subsequent Libyan-Berber II Period.

Taking into account that Oukaïmeden is an embedded valley, with marked boundaries from significant landforms, the analysis shows how MADO lines are located in the zones with better accessibility although these not necessarily are the ones with higher visibility indices. As expected, the higher mountains of the area are the zones with greater visibility. Despite this, 89,9% of the

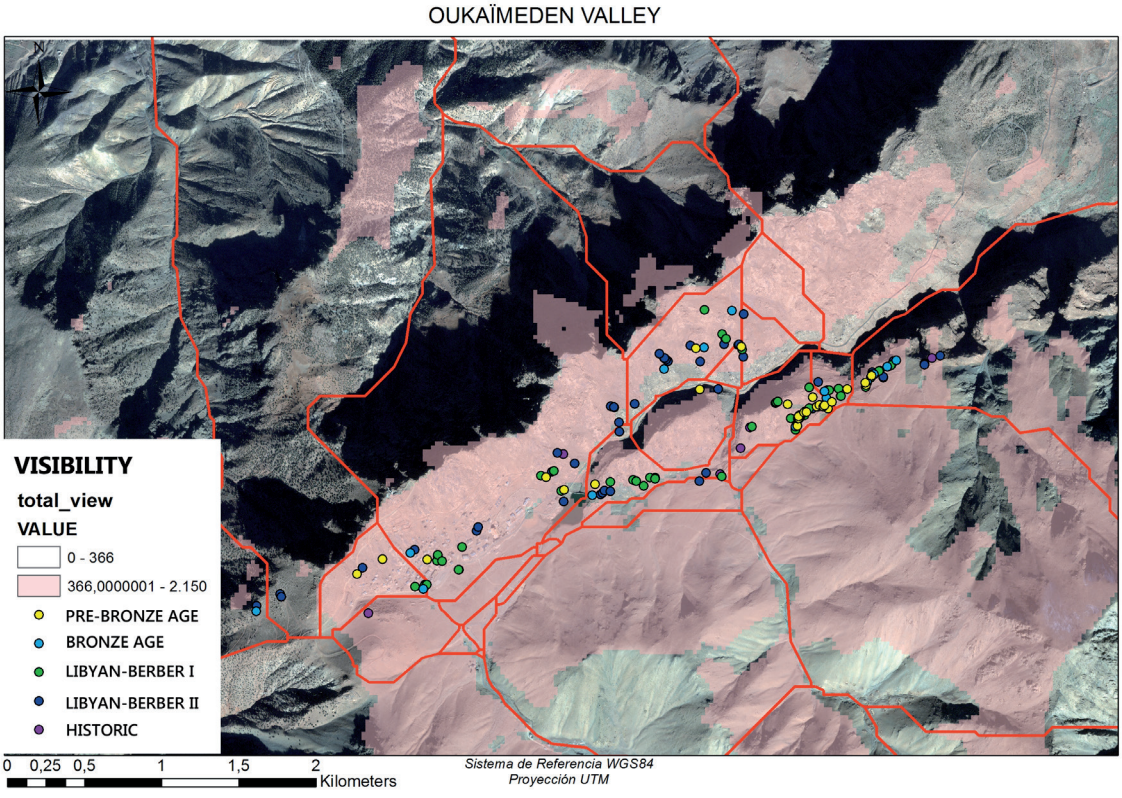

Fig. 10. Area with visibility indices above standard deviation.

carvings have visibility indices above the standard deviation from the MADO lines, what means that most of the rock carvings were under visual control. These indices are the same independently of the chronology (fig.10).

Vegetation Analysis of the Oukaïmeden Valley

The analysis done is the so–called Normalized Difference Vegetation Index (NDVI) and basically consists of an index that serves to measure the growth of plants and determine ground covers.

The NDVI is calculated from the information obtained from red and near-infrared bands following this formula:

$$NDVI = (NIR - red) / (near\text{-}infrared + red)$$

The range of values of the spectral reflection is between 0 and 1; since both near-infrared reflectivity as red are ratios of the reflected radiation on the incoming radiation.

Consequently these ranges of values, the NDVI value varies between -1 and 1.Therefore, considering that the NDVI always results in a number between -1 and 1, because of the way they are calculated, we could say that an NDVI <0 corresponds to artificial covers or water areas; NDVI between 0 and 0.3 corresponds to bare soil, and high NDVI corresponds to vegetational zones.

NDVI <0, corresponding to water, water reservoirs or buildings.

0 <NDVI <0.2, corresponding to bare soil or dead vegetation

0.2 <NDVI <0.4, corresponding to sparse or not very vigorous vegetation

0,4< NDVI < 0,6, corresponding to copious and vigorous vegetation

(NDVI > 0,6, corresponding to a very rich and vigorous vegetation.

In comparison to other more complex vegetation indices, NDVI has many advantages. It is very simple to calculate and it also provides a direct interpretation of biophysical parameters of vegetation, identifying the presence of green vegetation and characterizes their spatial distribution, their evolution and their condition over time.

	ANTHROPOMORPH	WEAPONS	ETHNOGRAPHIC ELEMENTS	IDOLS	SYMBOLS	ZOOMORPHS
Maximum	280,4302393	334,6600959	317,9268643	142,2335488	292,7651433	292,7651433
Minimum	2,24724156	2,24724156	18,67664551	25,87108171	0,212217305	10,6246885
Average	95,66348187	90,99665751	104,4600382	84,43809186	92,53809256	130,0413584
Standard deviation	63,51366779	62,16072291	71,10441397	37,79843875	77,60889922	94,81998639

Table 2. Distances between MADO lines and different types of rock art figures.

Linking data

The impossibility to obtain quality mapping of the study area has determined the low resolution of the DEM, hindering the precision of the analysis of the archaeological data. The heterogeneity of the archaeological information has been a second trouble we had to cope with. Nevertheless, we decided to cope with all this and try and extract as much information as possible with the tools we had.

Despite of it, we can see some general trends concerning the geolocation of rock art stations and of tumuli that allow a better understanding of the valley organization. They have been based on the combination of several previous analyzes, which detected the areas with greatest accumulation of movement, the most humid zones and the best grazing areas, as these three factors can be considered of vital importance among pastoral societies.

On the one hand, and regarding to the mobility of humans within the valley, it seems to be a certain connection between tumuli and Pre-Bronze Age rock carvings and the control of the MADO lines of movement On the other hand, between Bronze Age and Libyan-Berber Period II, rock art stations tend to be situated close to wet areas and meadows, although this tendency drops in historical times to levels similar to those of Pre-Bronze Age (fig. 11). Tumuli too are located very close to wet areas and meadows, maybe implying a tighter control over resources.

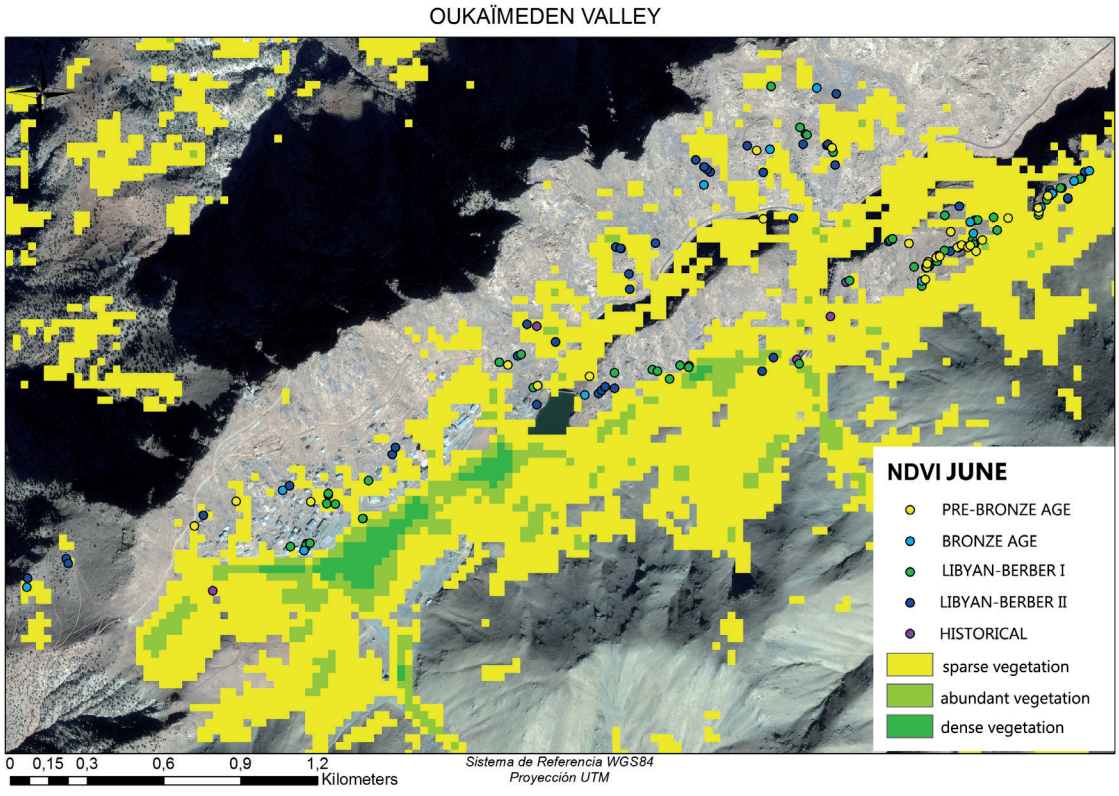

Fig. 11. NDVI vegetation index of June and location of rock art.

	PRE-BRONZE	BRONZE	LIBYAN-BERBER I	LIBYAN-BERBER II	HISTORICAL
MAXIMUM	50,1	76,1	67,9	76,9	53,7
AVERAGE	17,7	19,2	17,5	17,4	12,7
STAND. DEV.	17,0	18,6	20,1	21,3	16,0

Table 3. Distances between wet areas and rock art.

While we have been unable to identify boundaries between groups through the rock carvings, it seems probable either an increase in human groups profiting the valley resources, or a greater pressure on resources during the Libyan-Berber I, which would be manifested in the significant augment of rock carvings in the valley connected with movement areas as well with pastures.

Unfortunately, all the tumuli excavated by the project's team, were already either fully excavated by Malhomme (1953b), or carefully emptied by plunderers. Therefore, there is no information at all which could help us to date them. Published information on tumuli tombs in Morocco is scarcely useful for that case. Our tumuli belong to three types: big tumuli controlling passes, as those of Oukaïmeden to the west and *Igountar* to the east, or the one with corridor, located in the middle of the valley, approximately where it was laid the border between the current tribes of *Ourika* and *Rheraya*, the Tizi *n'Outt* or frontier pass (Mahdi 1999), that ran through the point where nowadays a dam is located. Some others are smaller and are scattered on flatter areas close to the pastures. Eventually, the third type are cist graves under very inconspicuous tumuli[1]. Other types as tumuli with lateral chapels, (Bokbot 2003) or of crescent (Souville 1998), platform (El Graoui *et al* 2010; Bokbot *et al* 2011) or keyhole types, are totally absent (di Lernia *et al* 2002:29), except for some stone appendices in tumulus C600 that might have been arms. According to Souville (1959, 1968), they could be classified as pre-Islamics and they contain a variable number of individuals, from just one or some few corpses (Souville 1968:419), to several or many (Jacques-Meunié 1958:103, 111 etc; Margat and Camus 1958-59). The simplest ones do not include grave goods (*ibidem* 1959:396). Others are referred as containing copper, bronze or iron items, but not further description or drawing is produced. Eventually, others with cist under tumulus, could belong to a Punic-Mauritanian period (*ibidem* 1959: 398), since Boudouhou (1997) publishes an inhumation in cist under tumulus in the North-western Morocco, together with some bone fragments and wheel made sherds and an iron item. Nevertheless, no plan of the burial structure is included and the only one published photo focuses on the cist. While there are some recent 14C dates for some kind of complex tumuli, as those with platforms, they place them in the first centuries AD (El Graoui *et al* 2010:79; Bokbot *et al* 2011:320). Others are dated more loosely, from the Punic-Mauritanian period onwards.

Those that, according with the simplicity of their architecture resemble more closely to our tumuli in Okaïmeden are some of the tumuli excavated in the Libyan *Taneffuft* valley by the Italian team of *La Sapienza* University (di Lernia *et al.* 2002: 28-29). Generally speaking platform tumuli with arms and V form, are dated by AMS to a prehistoric period, as are most of the tumuli structures (di Lernia *et al.* 2002: 27 and ff; di Lernia *et al*. 2002: 282 and ff). The Tumulus 1 in *Anghelachem* (di Lernia *et al* 2002: 99 and ff) offers some similarities with the tumulus C600 in Oukaimeden, as the existence of a central cist, the shallow tumulus or some badly preserved arms. *Anghelachem* tumulus 1 contained a single burial of an adult male with no other grave goods than ostrich eggshell beads. One sample on bioapatite was dated by AMS to 3350-2550 calBC $(2\sigma)^2$, although the chronology could be even older as bioapatite samples tend to rejuvenate the age (di Lernia *et al.* 2002: 99; di Lernia *et al*. 2002: 282 and ff). Also *Taneffuft* tumulus 6, made of a circle of big stones with the interior filled by smaller stones, is architecturally similar to some of the tumuli of Oukaimeden. It contained a single burial of a child, together with an ostrich shell bead and some sherds of pottery. It was dated to 1690-1490 calBC (2σ), on an AMS sample of bone (di Lernia *et al.* 2002: 99; di Lernia *et al.* 2002: 282 and ff). Some comparisons could also be made between the tumuli of Oukaïmeden and the *Taneffuft* 43 tumulus, dated to 1690-1490 calBC (2σ), by a bone sample from the single adult corpse buried there, together with eggshell beds and some sherds, (di Lernia *et al.* 2002:79). Also with *Taneffuft* Tumulus 10 of site 96/129, dated to 1750-1530 calBC. (2σ), again from a bone sample of one of the four corpses, two adult women and two children buried there (di Lernia *et al.* 2002:149 and ff). Both tumuli consist of a stone platform, forming a compact but inconspicuous structure with a more or less central cist or pit.

	ANTHROPOMORPH	WEAPON	ETNOGRAPHIC ELEMENT	IDOL	SYMBOL	ZOOMORPHS
Maximum	448,7159458	560,8029957	507,8907363	240,2602755	504,9326688	459,8478009
Minimum	11	0	1	90	0	0
Average	171,4716426	168,0054855	163,346304	190,3312026	149,4802403	186,3192051
Standard Deviation	91,77180464	102,1558086	134,9013876	46,37928502	126,8840059	148,345595

Table 4. Distances between wet areas and different types of rock art figures.

Although we can suggest some formal similarities with the prehistoric tumuli of the *Taneffuft* valley, we lack of any archaeological data that could help dating the Okaimeden tumuli. Anyhow, Onrubia *et al* (1996), published some years ago two very simple and shallow tumuli, erected on a littoral dune in *Tarfaya* (W Morocco), one of them with a central cist. One of these structures was apparently empty, but the other enclosed a single burial together with some ostrich eggshell beads. Surface findings of flint industry as well as the vicinity to a Neolithic site suggested a chronology of Late Neolithic to the authors.

Summing up, although unfortunately we cannot assign chronology the tumuli burials of Oukaïmeden, some clues may suggest a prehistoric chronology, between the late Neolithic and the Bronze Age, for these inconspicuous tumuli. If this would be the case, then the link between Pre-Bronze rock carvings and tumuli with the MADO lines of movement would gain interpretative weight. But, sadly, we cannot go further.

A second group of analysis carried out, were those related to visibility from different parameters: art panels or art panels oriented and MADO. Several conclusions can be drawn from them. On the one hand the visual control of the valley increases during the Libyan-Berber II period, as reflected in the greater amount of rock art of that period. On the other, viewsheds from MADO reveal a wide visual control of the entire rock art from the different routes of mobility.

In short, the different analysis conducted, suggest an attempt of physical and symbolic appropriation of the valley resources by means of rock art and burials. Our point is that a first step in the process might have been the depiction of animal carvings, especially bovines, and the building of tumuli, the first ones connected with the profit of summer pastures and the seconds, with claim of rights through the ancestors. A second step is suggested by an increased unrest, along the Second Millennium B.C. i.e. the Bronze Age. On the one side, depictions of weapons (halberds and grooved daggers), made its appearance as insignia of military power. On the other, engravings came closer to wet areas. A step further in the path of conflict seems to have taken place in the transition from the Bronze Age to the Libyan-Berber Period, when the reclamation of rights on critical resources is expressed by the appearance of human depictions, connected at first, to the previous power insignia - halberds and grooved daggers -, but quickly substituted by arrows, spearheads, shield-like depictions and non grooved daggers. They sometimes compose scenes, perhaps narrating the murder of a heroic ancestor in combat, as happens in other pastoral areas (Thapar 1981; Bernus, E. 1990:154 and ff).

As the Libyan-Berber period progresses, the complex scenes where warriors seemed to be attacked or killed gradually disappear. Figures of warriors tend to have an increasingly schematic outline and are represented isolated or in pairs, with arms and legs outstretched. The rich panoply of the early stages of this phase is substituted by a much more reduced set of weapons; usually just a dagger with a very simplified round-edged or squared hilt and in some cases a rectangular shield. The general meaning of the figures, however, shows a strong continuity with former periods, indicating a tension in the valley made explicit by the engraving of symbols with an aggressive iconography.

Climatic and environmental information give us support to this interpretation. In fact, our hypothesis at the beginning of the project was, that the valley of Oukaïmeden was never permanently settled until very recently in historical times, and that its first human use took place relatively late, at the Mid-Holocene, when worse and drier climatic conditions, were translated in our study area into a marked seasonality between lowland and upland resources (Ruiz-Gálvez et al 2013:287). Archaeological and 14C data gathered in the frame of the project, support this point, as the oldest information on the human systematic use of the valley resources goes back to the Late Neolithic and to the transition between the IV and III Millennia calBC. and to the transition to the Subboreal period. It is precisely then, when the first symptoms of forest degradation, advance of a steppe vegetation, aridity, and human

impact are detected through paleoenvironmental analysis carried on wet areas of the High Atlas, Anti Atlas, *Oudja* mountains and Western Rif mountains (López & López 2008: 3-5). These data are in tune with those obtained on other high mountain points at the other side of *Gibraltar* Straight, as *Pinilla del Valle* archaeological site and a wetland, both in the *Rascafría* mountain range and el *Portalón* in the *Atapuerca* mountains (Ruiz et al 2008:2; Ruiz et al 2004). According to them, prior 3500 cal BC, environmental conditions were relatively temperate, and became gradually drier afterwards. These alterations are linked in Northern Africa with those caused by changes in the Intertropical Convergence Zone (ITCZ), translated into a decrease in the monsoon intensity in the area, and the development of the Sahara (Damnati 2000; Brooks 2006). These factors explain the first human impact in many high mountain environments, as in the present case. Anyhow, it should bear in mind that the first traces of human exploitation of high mountain landscapes is connected to worse and drier conditions in the lowlands.

A second important environmental event happens in the Bronze Age. Our pollen sequence points to a period around the mid Second Millennium calBC of lower rainfall, translated into a more open landscape with more xerophytic taxa. Again this is not an isolated case but, quite on the contrary, matches with other analysis made as much in the Maghreb area as in many Mediterranean wetlands and lakes (Ruiz 2004:89-90; Fletcher & Zeilhofer 2013). Such event is attributed to short and rapids climatic changes within the Holocene Period (RCC), that in the case of Iberia are sharply marked around 1600-1500 cal BC (Fábregas et al 2003; Carrión et al 2007:1461; Martinez *et al.* 2009).

We know now, thanks to paleoclimate reconstructions, that the Holocene Period has been punctuated by many short and rapid events of climatic change (RCC). One of the best recorded, almost everywhere, is the 2800 calBP event, that took place at the transition from the Second to the First Millennium cal BC (ca. 850 cal BC), i.e. around the Subboreal-SubAtlantic transition. These changes induced by major changes in solar irradiance, were translated into cooler and wetter climatic conditions in the Northern Hemisphere, but into drier and arid conditions in the Southern Hemisphere (Van Geel et al 2001). Again this event is well attested at both sides of the Gibraltar Straight. (López et al 2009:97; Fletcher & Zielhofer 2013:23). As mentioned above in our case study the hypothesis is that the increase in weapons depictions in the Libyan-Berber I Period is connected with an increment in rivalry and conflict for the control of a critical resource as the high mountain pastures. Environmental data from the *Sidi Ali* Lake, located at 2080 m above sea level, in the Mid-Atlas Mountains, gives us a clue about the climatic changes in the area. According to the pollen analysis, which records the last 7000 years, the first human impact in the area took place around 3000 cal BP or 1050 calBC, still under relatively mild climatic conditions (although probably already worsening in the lowlands) (López & López 2008:4). Additionally, an environmental sample of Oukaïmeden dated between 1010-840 calBC, shows a wetter context with recovering of forest vegetation (See Chapter Vegetation). As B Ruiz[3] explains, the drier the conditions at low and mid altitudes, the greater is the tendency to rely on high mountain resources.

In this context, the emergence of the human figure in the Oukaïmeden's art imagery first, and of combat scenes - the so-called *Supliciées* -, later, could be understood as a mirror of this increased tension about resources. This tendency seems to follow suit in the following Period, implying that pressure over resources continued during a significant part of Libyan-Berber Period II. What we have called Libyan-Berber II is mainly characterized by a trend towards greater schematism and simplicity. Other parameters, as the type and occurrence of images and their position within the landscape remain essentially the same than Libyan-Berber Period I. As aforementioned, no rider's scenes have been documented in Oukaïmeden insofar, although some schematic animals of this period have been identified during this project. The discussion about the diachrony or synchrony of both types of depictions (warriors and weapons versus riders) has been dealt with somewhere else (See Chapters Art & Statistics), but most evidences point to a later chronology for the schematic riders, which would be coetaneous of last stages of frontal anthropomorphs in the High Atlas style (Ezziani 2004a: 562) and eventually would became the generalized style elsewhere.

The almost total absence of these engravings in Oukaïmeden raises questions about the evolution of the symbolic control of the valley. If the increasing pressure over resources led to the development of a complex set of iconography linked to the figure of the warrior/ hero, can the disappearance of this type of images imply a decrease in the previous strain? Unfortunately, the archaeological knowledge of the Libyan-Berber period in the High Atlas is still in its early stages, and no clues have been found yet to solve this question. Although the disappearance of engravings could be explained by an improvement of environmental conditions or a decrease of the pressure over resources, there are some alternatives that could have also led to the radical decrease

of engravings in Oukaïmeden. These could include the presence of a higher authority imposing agreements, or the development of alternative ways to regulate pasture rights, much in the way it still happens today. Therefore, the decrease of engravings would not have necessarily to imply an improvement of environmental conditions in Oukaïmeden, just a change of strategy of the control of the valley, one whose physical evidences have not lasted until today.

Summary

Through the above described analyzes, we were able to establish a rough classification of the different types of vegetation in the valley, with particular attention to areas that still remained flooded in summer, as they were a critical resource for grazing, when the drought had already started in the lowlands. From there, we have tested the degree of human control on the several wet and grazing zones over time. As reflected in table 3, average distances of engravings to wetlands decreases a little during the Bronze Age respecting to the Pre-bronze Period, but recovered during the Libyan-Berber I and II Periods (See table 3).

Nevertheless, as weapons of different chronologies are, together with the category "signs", the most frequent depiction connected to wet areas, it could be assumed, that they were used as symbolic device to sanction rights on grassland use (See table 4).

As mentioned above, although the variability y of data can hinder the interpretation of the general framework, nevertheless we can see some trends. For instance, the number of carvings increases dramatically during the so-called Libyan-Berber I Period. Although it should be taken into account that we are dealing with somehow biased information, due to post-depositional processes, as damage or even, destruction of a part of the rock art stations, nevertheless it is relevant that Pré-Bronze and Bronze Age carvings account for just 11% and 12% respectively, of the total amount, while those attributed to the Libyan-Berber Period I represent 28%. So, it seems that the increased Libyan-Berber I carvings and its concentration around grazing areas could betray an increment of pressure on the pasturages.

Notes

1. E. Galán personal communication.
2. Oxcal 3.10 Program.
3. Personal communication.