Routledge
Taylor & Francis Group

Environmental Archaeology
The Journal of Human Palaeoecology

ISSN: 1461-4103 (Print) 1749-6314 (Online) Journal homepage: http://www.tandfonline.com/loi/yenv20

Late Glacial Landscape Dynamics Based on Macrobotanical Data: Evidence From Ifri El Baroud (NE Morocco)

Yolanda Carrión Marco, Paloma Vidal-Matutano, Jacob Morales, Pedro Henríquez Valido, Alessandro Potì, Martin Kehl, Jörg Linstädter, Gerd-Christian Weniger & Abdeslam Mikdad

To cite this article: Yolanda Carrión Marco, Paloma Vidal-Matutano, Jacob Morales, Pedro Henríquez Valido, Alessandro Potì, Martin Kehl, Jörg Linstädter, Gerd-Christian Weniger & Abdeslam Mikdad (2018): Late Glacial Landscape Dynamics Based on Macrobotanical Data: Evidence From Ifri El Baroud (NE Morocco), Environmental Archaeology

To link to this article: https://doi.org/10.1080/14614103.2018.1538088

Published online: 29 Oct 2018.

ENVIRONMENTAL ARCHAEOLOGY
https://doi.org/10.1080/14614103.2018.1538088

Late Glacial Landscape Dynamics Based on Macrobotanical Data: Evidence From Ifri El Baroud (NE Morocco)

Yolanda Carrión Marco [a], Paloma Vidal-Matutano [b], Jacob Morales [c], Pedro Henríquez Valido [c], Alessandro Potì [d], Martin Kehl [e], Jörg Linstädter [f], Gerd-Christian Weniger [g] and Abdeslam Mikdad [h]

[a]PREMEDOC – GIUV2015-213, Departament de Prehistòria, Arqueologia i Història Antiga, Universitat de València, València, Spain; [b]CEPAM, CNRS, Université Côte-d'Azur, Nice, France; [c]Departamento de Ciencias Históricas, Universidad de Las Palmas de Gran Canaria, Las Palmas, Spain; [d]Institute of Prehistoric Archaeology, University of Cologne, Albertus-Magnus-Platz, Cologne, Germany; [e]Institute of Geography, University of Cologne, Albertus-Magnus-Platz, Cologne, Germany; [f]German Archaeological Institute, Commission for Archaeology of Non-European Cultures, Bonn, Germany; [g]Neanderthal Museum, Mettmann, Germany; [h]Institut National des Sciences de l'Archéologie et du Patrimoine, Rabat, Morocco

ABSTRACT

The site of Ifri El Baroud has one of the longest sequences excavated in recent times in NE Morocco, covering a chronology of *ca.* 23–13 ka cal BP. The sequence includes Early and Late Iberomaurusian levels and offers the possibility of investigating the economic, social and environmental processes that took place during this period. In this paper we present the results of the charcoal analysis carried out at the site with the aim of reconstructing environmental alterations and changes in the use of forest resources between the LGM and the end of the Pleistocene. These results form part of multidisciplinary studies aimed at revealing the role of climatic and environmental changes in the great cultural transitions of the Late Palaeolithic. The results of the charcoal analysis show continuous exploitation of *Juniperus/Tetraclinis* formations throughout the sequence, so they must have been a fundamental part of the area's landscape. These data indicate that the climatic changes occurred during the study period, and according with other environmental proxies, did not have a very significant impact on the woody vegetation of the region.

ARTICLE HISTORY
Received 14 May 2018
Revised 30 September 2018
Accepted 10 October 2018

KEYWORDS
NE Morocco; Iberomaurusian; Late Pleistocene; Early Holocene; plant macroremains; landscape

Introduction

Ifri El Baroud (Eastern Rif, Morocco) is a reference site for research on the Late Pleistocene in North Africa, as it includes Early and Late Iberomaurusian levels covering a chronology between roughly the LGM and the onset of the Younger Dryas (*ca.* 23–13 ka cal BP). This area has also been the focus of various works on Neolithisation, which make a critical analysis of the last hunter-gatherers (Görsdorf and Eiwanger 1999; Linstädter et al. 2012, 2016), reconsidering the influence of environmental changes on human dynamics during the Holocene (Zapata et al. 2013). However, although some palaeoenvironmental studies have been carried out for the Late Pleistocene in the region, these works have focused more on the Pleistocene-Holocene transition or more recent chronologies (Couvert 1976; Couvert and Roche 1978; Wengler and Vernet 1992; Zapata et al. 2013), as well as aspects such as diet and basketwork (Humphrey et al. 2014), but few of them deal with palaeovegetation.

The latest work carried out at Ifri El Baroud is very much concerned with this discussion, as it is part of a multidisciplinary project aimed at understanding the environmental conditions, exploitation of forest resources and human settlement in NW Africa during the Last Glacial Maximum and the Younger Dryas (*ca.* 30–11.5 ka cal BP). The studies carried out have taken the form of several specific actions, such as the *Early Holocene Contacts between Africa and Europe and their Palaeoenvironmental Context* project (CRC 806 Projects C2), which discusses the role of climatic and environmental changes in the Epipalaeolithic-Neolithic transition within the general context of Neolithisation of the SW Mediterranean, and the PALEOPLANT project (ERC 2013 CoG 614960), which focused on the study of how plants were used during the Palaeolithic and Epipalaeolithic periods.

In some Western Mediterranean regions, human groups from the end of the Palaeolithic would have played a significant role in Neolithisation processes (Linstädter 2011) and, similarly, the climatic events that took place in the Pleistocene-Holocene transition (Bølling, Allerød and Younger Dryas) could also have influenced human occupation of the region to a greater or lesser extent (Barton et al. 2013; Bouzouggar et al. 2008; Cacho et al. 1999; Linstädter et al. 2016, 2018).

In general, the effect of climate and environmental change on land use by prehistoric societies is a major

CONTACT Yolanda Carrión Marco yolanda.carrion@uv.es PREMEDOC – GIUV2015-213, Departament de Prehistòria, Arqueologia i Història Antiga, Universitat de València, Av. Blasco Ibañez 28, 46010 València, Spain

topic. The extensive sequence of Ifri El Baroud, which covers an approximate chronology between roughly 23 and 13 ka cal BP (Potì 2017), offers great opportunities to assess the possible interaction between the environmental dynamics and cultural changes. Indeed, the chronological range of this sequence includes some of the most important environmental events of the Last Glacial cycle (Cacho et al. 1999, 2000, 2006; Moreno et al. 2005; Sánchez Goñi et al. 2002), which had effects on human communities in this study region that are worth investigating further. Few palaeoenvironmental studies have been carried out for North Africa in general, especially studies that allow us to distinguish local components of the landscape, which are the best unit of analysis to obtain high-resolution data about the plant catchment area (Ward 2007; Zapata et al. 2013). The purpose of this work is to fill this gap in our knowledge by studying the plant macro-remains recovered at the site of Ifri El Baroud. This type of remains provides information about the surroundings of the cave, which was exploited by its inhabitants, and allows us to make inferences about patterns of exploitation of the landscape, the use of plant materials in subsistence economies, etc. The sequence of Ifri El Baroud has been extensively dated (Görsdorf and Eiwanger 1999; Potì 2017) and offers a broad framework in which to determine the effects of the climate fluctuations that occurred during this period in terms of continuity/discontinuity in human dynamics during the Late Palaeolithic. In addition to this, macrobotanical data from this site will help increase our understanding of how forests were managed prior to the introduction of agriculture.

The Site. Biogeographical and Archaeological Setting

The cave-site Ifri El Baroud is located in north-east Morocco on the Ich Chaboun massif at an altitude of 539 m. It lies *ca.* 50 km from the present Mediterranean coast, opening out over the alluvial plain of Gerrouaou (Figure 1). This plain is framed by watercourses, Oued Bou Frah to the west and Oued Moulouya to the east, and by areas of relief that rise to an altitude of about 1000 m between the Atlas and Rif mountain systems.

The region falls under the Mediterranean climate, like most of the Maghreb (Quézel 1978; Rivas-Martínez 1987). The Eastern Rif area has cool, wet winters and a dry season in summer, although there is a decreasing rainfall gradient from the sub-humid mountain areas to the semi-arid plain (Ward 2007). The meteorological data for the city of Saka, 19 km from the site, show an average annual temperature of 16°C and 340 mm of precipitation, i.e. it lies within a thermo- to lower meso-Mediterranean biogeographical zone with precipitation typical of a semi-arid climate (Rivas-Martínez 1987).

Recently, the entire area has undergone arid conditions resulting in landscape without significant arboreal vegetation that is dominated by steppe formations consisting of alfa grass (*Stipa tenacissima*).

Ifri El Baroud measures approximately 12 m wide and 23 m deep. The site has been the object of several excavation campaigns since the 1990s. In 1995–1996, the Institut National des Sciences de l'Archéologie et du Patrimoine (INSAP) and the Commission for Archaeology of non-European Cultures (KAAK) of the German Archaeological Institute (DAI) carried out four surveys (three inside the cave and one outside) (Nami 2007). At that time, archaeologists performed testing over four trenches (labelled I, II, III, IV), using 1 m^2 grid and 10 cm artificial horizontal spits. During 1995 and 1996 field seasons only dry sieving of the sediments could be employed, thus resulting in a very limited recovery of small organic and inorganic remains. Apart from preliminary studies of lithic and faunal materials, no information about geomorphological, spatial or cultural features has been produced. Nevertheless, these surveys made it possible to establish an initial definition of the Iberomaurusian sequence and confirmed the archaeological wealth of the levels. First studies of the archaeological and palaeontological material led to several publications (Ben-Ncer 2004; Eiwanger 1992; Eiwanger and Mikdad 1997; Mikdad and Eiwanger 2000; Mouhsine 1998; Nami 2002, 2007). At the back of the cave Epipalaeolithic-Neolithic deposits were also documented during the first campaigns in the 1990s, although they are not continuous and systematic sampling was not used to recover the botanical remains.

Later, in 2015, an excavation campaign was carried out as an extension to Survey 2, located in the central-north sector of the cave (Figure 2). The primary aim of this new phase of work at the site was to re-explore the Iberomaurusian deposit in its entirety (with more advanced standards of documentation) and collect new high-resolution samples for a detailed chronological, palaeoenvironmental, archaeological and geological reconstruction (Potì 2017). The material presented here has resulted from this second excavation campaign.

Ifri El Baroud is one of the few sites in the Maghreb that includes a complete Iberomaurusian sequence (Barton et al. 2005; Bouzouggar et al. 2008; Moser 2003; Linstädter 2011; Linstädter et al. 2012; Potì 2017; Richter et al. 2010), providing high-resolution data for the time interval between the LGM and the Younger Dryas. From the chrono-stratigraphic point of view, the sequence of Ifri El Baroud has been divided into four major units (Potì 2017): unit A, corresponding to the Epipalaeolithic-Neolithic (which is not covered by this study), and units B, C and D,

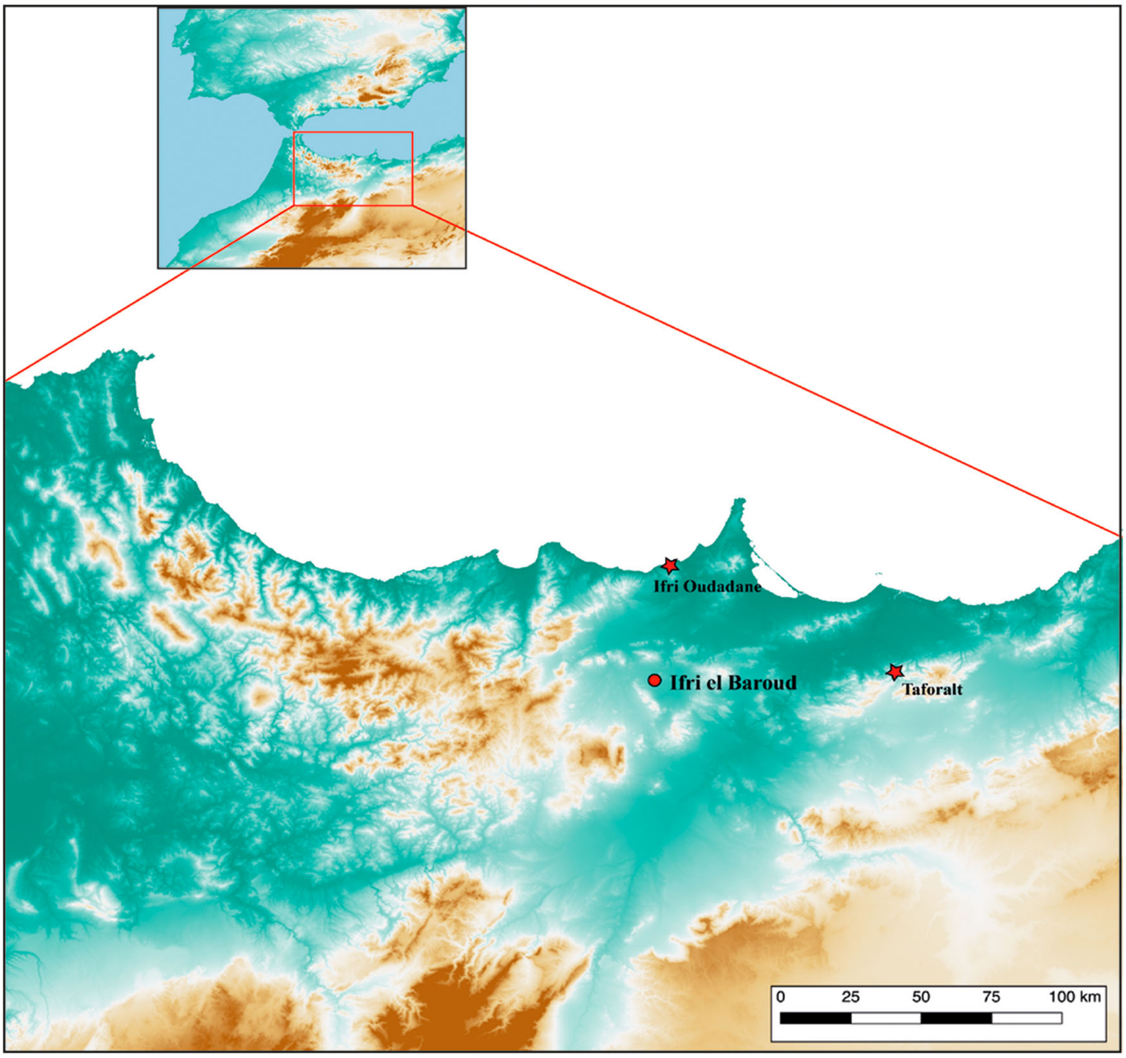

Figure 1. Location map of Ifri El Baroud and other sites mentioned in this work.

corresponding to the Iberomaurusian levels documented throughout the excavations. The stratigraphy of the site presents about 3 m of thickness, consisting of a base package with very fine, compact yellowish sediment with few archaeological material ('Couche Jaune' or Unit D), a reddish-brown package with sandy sediment rich in charcoal ('Couche Rouge' or Unit C), and a thick greyish 'Escargotière' (Unit B) with an ashy texture and many land snails that shows more intense, recurring human activity (Nami 2007; Potì 2017). The transition from units D-C (Early Iberomaurusian) to unit B (Late Iberomaurusian) seems to correspond to the transition from Heinrich Event 1 to Greenland Interstadial 1, *ca.* 16–15 ka cal BP (Potì 2017). Eventually, Iberomaurusian occupations lasted at Ifri El Baroud until the onset of the Younger Dryas.

This stratigraphy, with a more compact sediment base that is poorer in archaeological material (matrix referred to as the 'Yellow Series') and a thick overlying 'Escargotière', is characteristic of the region and has been documented at other Iberomaurusian sites (Barton et al. 2013; Barton and Bouzouggar 2013).

Material and Methods

Sampling Strategy

The materials presented here come from the Iberomaurusian sequence. The macro-groups or Units described above were assembled on the basis of their homogeneity in terms of components and characteristics, thus reflecting similar depositional conditions. Nevertheless, the sequence was divided into 58 spits of approximately 5 cm during the excavation process, providing a fine-grained time-scale with high temporal resolution.

A total of 6920 L of sediment were processed by flotation system, which makes it possible to recover seeds, charcoal and other tiny plant materials included in the light fraction. Flots were sorted using a column of sieves with mesh sizes of 2, 1, 0.5, 0.25 and 0.1 mm. Charred botanical remains were very abundant and well preserved at the site.

For the anthracological analysis, as first results showed a great homogeneity throughout the sequence together with very low taxonomic diversity, horizontal and vertical sub-sampling was used, given the

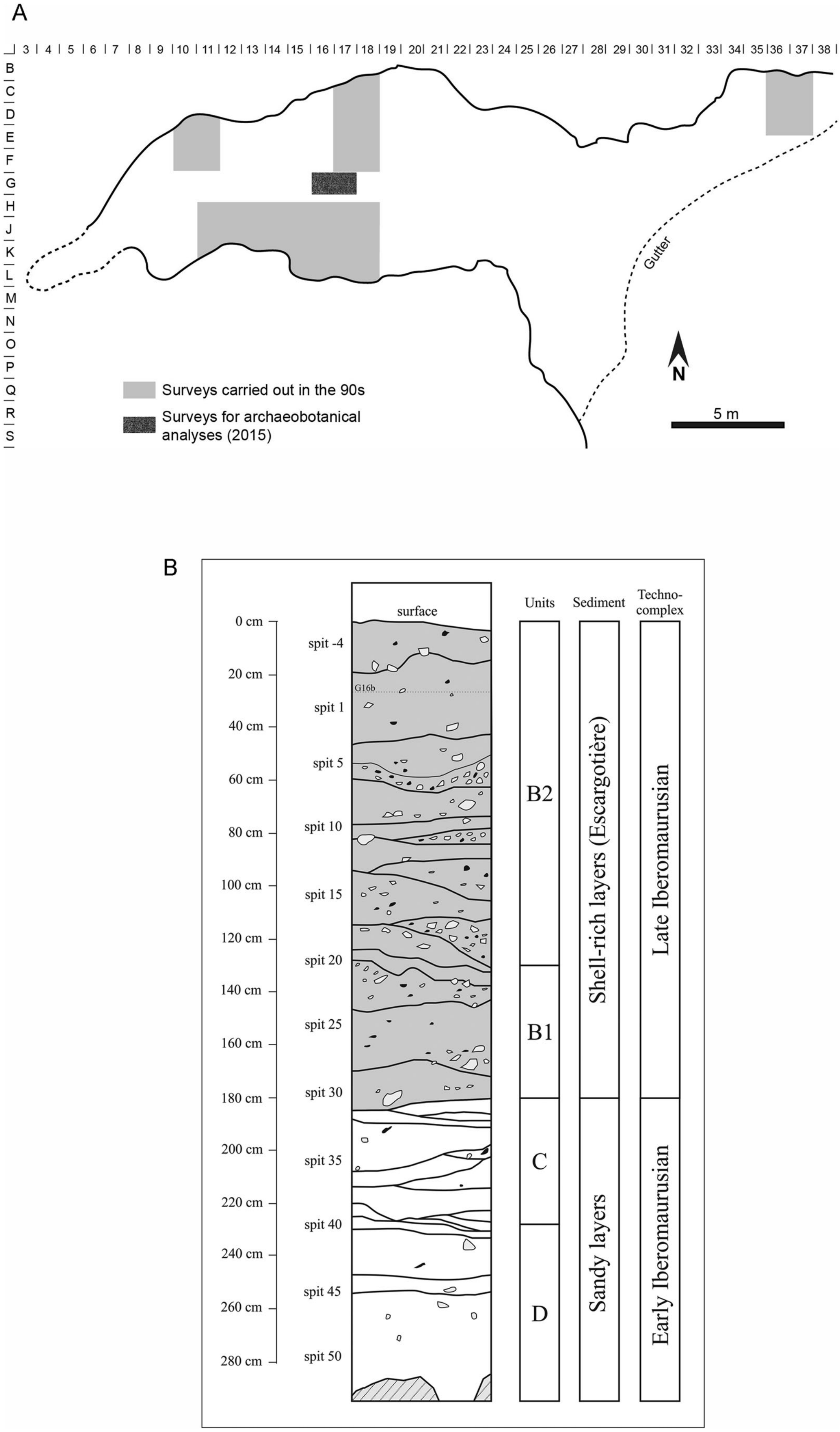

Figure 2. (A) Plan of the excavated area of the site. (B) Schematic section through the Iberomaurusian layers (square G17b) (macro-Units assignment is valid for the sequence studied in subsections G17a, G17b, G17c and G16a).

homogeneity of materials and sediments along the sequence. A column in subsections G17a, G17b, G17c and G16a was selected based on its higher stratigraphic reliability, according to other archaeological evidences.

In the same way, the large amount of charcoal fragments recorded in the flots from Units B and C, as well as the rapid sedimentation and thick deposits without significant sedimentary differences, has led to a vertical subsampling analysing a charcoal sample every 15 cm. For Unit D, all the charcoal recovered has been analysed. Taking into account that scattered charcoal assemblages are a mix of several combustion events and depositional/postdepositional processes (spreading of fuel remains along the human occupation surfaces) vertical sub-sampling following the archaeological stratigraphy of the site constitutes a suitable method to provide palaeoenvironmental data (Chabal 1997). For each of these anthracological samples a minimum of 100–150 charcoal fragments were analysed, ensuring that the samples were taxonomically stabilised (Chabal 1997).

Botanical Identification

Charcoal analysis was based on the botanical identification of carbonised wood, i.e. determining which species the charcoal is derived from. Each fragment was examined under a reflected light brightfield/darkfield optical microscope with different lenses ranging from 50x to 1000x magnification. The anatomical features of the wood were compared with specialised literature on plant anatomy (Greguss 1955, 1959; Jacquiot 1955; Jacquiot, Trenard, and Dirol 1973; Neumann et al. 2001; Schweingruber 1990, among others) and a modern reference collection of charred wood. The charcoal was analysed in the Milagro Gil-Mascarell Laboratory of Prehistory and Archaeology at the University of Valencia, where there is a complete collection of Mediterranean woods, including numerous woody species from North Africa.

For the standard analysis, charcoal was broken manually and no chemical treatment was required. With this technique radiocarbon dating can be applied to the samples at a later stage (Vernet, Bazile, and Evin 1979). For the observation of specific features and to take photos, we used a Hitachi S-4100 scanning electron microscope (SEM) located at the Central Service for Experimental Research Support (SCSIE) at the University of Valencia. The nomenclature used was that of *Flora Europaea* (Tutin et al. 1964).

A large quantity of charred remains from fruits and seeds were also recovered with the flotation system. They are currently being studied by JMM and PHV in the Laboratory of the Department of Historical Sciences at the University of Las Palmas de Gran Canaria, Spain. The preliminary results of this study will also be considered in the discussion together with the anthracological results.

Results of Charcoal Analysis

A total of 8281 charcoal fragments were identified at Ifri El Baroud, corresponding to at least 12 taxa. The entire anthracological assemblage is comprised of scattered charcoal fragments belonging to the excavated units. According to the standardised anthracological premises, scattered charcoal spread over human living surfaces is the result of several combustion events (Chabal 1997). As an average representation of cumulative processes resulting from an undefined number of occupation events, scattered charcoal fragments are mostly representative of the environment but difficult to link to a particular practice, while charcoal remains from combustion structures would represent a more accurate time record, offering an instant picture of the last firewood collecting activities in the supply area (Badal and Heinz 1991; Chabal 1988). Therefore, the scattered anthracological assemblages found at Ifri El Baroud enable us to obtain meaningful information about the dynamics of the local landscape over time.

The assemblages analysed are characterised by the strong presence of *Juniperus/Tetraclinis* (juniper/araar), with percentages of 65–95%, followed by Fabaceae (legume family taxa), with values ranging between 5 and 30% (Table 1, Figure 3).

Other taxa such as Compositae, *Ephedra* sp. (joint pine), *Fraxinus* sp. (ash), cf. *Hedera* sp. (ivy), Labiatae, Maloideae, Monocotyledoneae, *Quercus* sp. evergreen (evergreen oak), *Rhamnus/Phillyrea* (buckthorn) and *Salix/Populus* (willow-poplar) are occasionally present.

The high proportion of juniper/araar suggests the preponderance of open heliophilous plant formations, where the presence of woody legumes would have been considerable. The botanical identification of Fabaceae taxa remains difficult to interpret in a climatological context, as it is not possible to determine what type or types of genus are involved based on anatomical wood charcoal observation (Schweingruber 1976, 1990). With regard to *Juniperus* and *Tetraclinis articulata*, the main anatomical difference between these taxa is the presence of wedge-shaped cell walls around the bordered pits in *Tetraclinis* (Schweingruber 1990, 145), a feature that is absent in junipers and which can only (rarely) be confirmed by observation under SEM equipment. A morphometric study of samples from Ifri El Baroud compared with current individuals from the reference collection (some from the area of the site) did not provide conclusive results in terms of anatomical discrimination (as other variables related to combustion, conservation, etc. also influenced the observation of these anatomical features). Thus, we identified the taxon *Juniperus/Tetraclinis*, as already discussed by Zapata et al. (2013) or Carrión Marco et al. (2018) in other analyses of the region. The greater percentage of Coniferae at the base of the sequence (without being able to achieve a greater resolution of

Table 1. Frequencies of the taxa identified in the charcoal assemblage of Ifri El Baroud.

Cultural sequence	Early Iberomaurusian								Late Iberomaurusian									
UNIT	B2				B1				C				D					
Spits	−4 to 9		10 to 20		21 to 26		27 to 32[a]		32[a] to 37		38 to 41[a]		40[a] to 45		46 to 49		50 to 53	
Taxa	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Angiosperma	1	0.05	3	0.19	1	0.11	1	0.10	1	0.11	11	1.37	7	1.09	3	1.16	1	0.57
Compositae															2	0.77		
Coniferae	45	2.25	34	2.10	17	1.94	29	2.99	19	2.01	12	1.50	34	5.31	37	14.29	21	12
Ephedra sp.			2	0.12					1	0.11	3	0.37						
Fabaceae	192	9.61	238	14.73	105	11.96	61	6.30	40	4.23	239	29.84	98	15.31	8	3.09	11	6.29
cf Fabaceae			4	0.25	3	0.34	3	0.31	1	0.11	6	0.75	6	0.94	2	0.77	2	1.14
Fraxinus sp.	1	0.05																
cf *Hedera* sp.											1	0.12						
Juniperus/Tetraclinis	1758	88.03	1334	82.55	752	85.65	871	89.89	880	93.02	512	63.92	486	75.94	192	74.13	139	79.43
cf *Juniperus/Tetraclinis*									1	0.11							1	0.57
Labiatae							2	0.21	1	0.11								
Maloideae							2	0.21										
Monocotyledoneae											17	2.12	7	1.09	11	4.25		
Quercus sp. evergreen															1	0.39		
Rhamnus-Phillyrea			1	0.06														
Salix-Populus									2	0.21								
Indeterminable													2	0.31	3	1.16		
Total	1997	100	1616	100	878	100	969	100	946	100	801	100	640	100	259	100	175	100

[a] The limit between the macro Units is not horizontal, so that in the spit of the transitions between them, the same artificial spit can be divided into two Units, depending on the subsection.

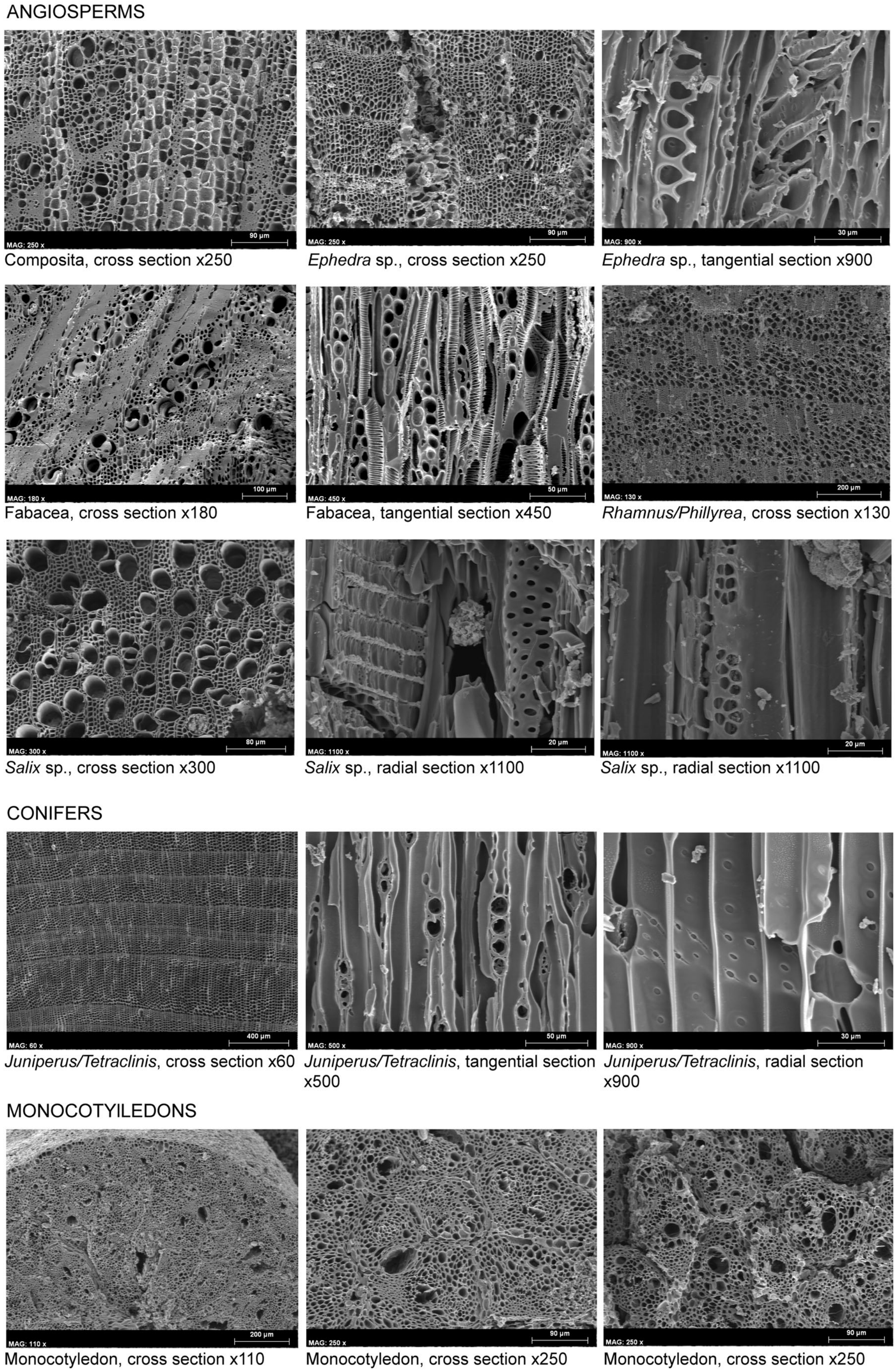

Figure 3. SEM photographs of some woody taxa identified at Ifri El Baroud.

identification) is due to the worse preservation and smaller size of the charcoal. This is consistent with the sedimentation found at the site, coinciding with the red sediments containing few archaeological materials in general and very small charcoal fragments (Potì 2017).

We do not rule out the underrepresentation of some angiosperms, which are especially sensitive to disappearance due to postdepositional processes or certain systems of sediment processing, as pointed out by some works carried out in arid environments indicating the underrepresentation of Salicaceae species (Arranz-Otaegui 2017). Although bias in charcoal analysis under-representing this family has been documented in a particular site, the fact is that most of the western Mediterranean Palaeolithic sites (from wet to dry environments) show little presence of riverine species. In this sense, ethnographic data show preferences regarding dry firewood selection, avoiding riverine plant formations (Henry and Théry-Parisot 2014). In addition, other studies have shown that the flotation system is the most suitable sampling method to recover a greater proportion of angiosperms, compared to other recovering methods (Vidal-Matutano et al. 2015). In any case, the spectra obtained at Ifri El Baroud show the dominant taxa used, which must have a direct relationship with their abundance and availability in the firewood collection area.

Discussion

Landscape Approach and Management of Plant Resources

The wood charcoal sequence from Ifri El Baroud provides valuable data to reconstruct the environmental history of north-eastern Morocco during the Last Glacial Maximum (LGM) and Late Glacial period. According to Chabal (1997), the anthracological record may offer significant palaeoenvironmental information if the analysis focuses on scattered charcoal from domestic use representing prolonged periods of activity, as is the case of the material studied at Ifri El Baroud, which covers the LGM and Late Glacial period. Despite the extensive time frame studied here and the chronological resolution of the sequence, the anthracological diagram of Ifri El Baroud does not show any significant changes in the vegetation exploited in the area under study (Figure 4); the entire sequence is characterised by the dominance of *Juniperus/Tetraclinis* and leguminous plant formations together with the presence of other taxa with very low percentages (Lamiaceae, *Ephedra* sp., *Fraxinus* sp., *Rhamnus/Phillyrea*, Maloideae, *Salix/Populus*, Asteraceae and *Quercus* sp. evergreen).

According to the anthracological data obtained, between *ca*. 23 and 13 ka cal BP, the area where the site is located was characterised by open plant formations of junipers and/or arars. The climatic conditions would have been marked by a cooler atmosphere than the present day, but above all by aridity. The homogeneous anatomical structure of the genus *Juniperus* does not allow us to identify the species collected, which could have been more thermophilous (*J. oxycedrus*, *J. phoenicea*) or more cryophilous (*J. communis*, *J. thurifera*, *J. sabina*) species, whose present-day range covers thermo-Mediterranean to supra-Mediterranean belts under dry or semiarid bioclimatic conditions (Costa, Morla, and Sainz 2005). Junipers form clear heliophilous forests in which plenty of light reaches the ground, allowing the growth of shrub species with similar ecological requirements (Charco 1999). Therefore, at heights above 1200 m a.s.l., *Juniperus communis* and *Juniperus thurifera* can coexist with thorny leguminous shrubs such as *Erinacea* sp. or *Cytisus* sp. (Charco 1999). However, at heights below 800 m a.s.l., more thermophilous juniper species such as *J. phoenicea* can appear alongside *Tetraclinis articulata* (Barathon et al. 2000). The low representation of taxa other than legumes (<5%) together with the presence of carpological remains of *Juniperus* and the complete absence of *Tetraclinis* in the record of this proxy suggests the widespread extent of juniper formations in the site's local landscape. Despite not being possible to determine the taxon *Juniperus* at species level, the absence of thermophilous junipers is consistent with a lower temperature range than at present.

The preliminary results of the analysis of seeds and fruit recovered at Ifri El Baroud, which are currently under study, showed another aspect of plant exploitation with the presence of species not recorded in the charcoal found at the site and which could have been collected for different purposes, other than for fuel. The data also suggest certain differences between the species recorded at Early and Late Iberomaurusian levels. In the Early Iberomaurusian level, it is mainly seeds of *Juniperus*, Lamiaceae and small seeded legumes that have been documented. Wild legumes could have been gathered to be consumed, while seeds of *Juniperus* may have arrived together to the wood used as fuel, which has been recorded by charcoal analyses. At the level of the 'Escargotière' (Late Iberomaurusian), the most abundant remains belong to the tribe Fabeae, part of the legume family. This group includes seeds of the genera *Vicia, Lathyrus* and *Lens*, which are characterised by their large size and high carbohydrate and protein content (Butler 1998). There are ethnographic references relating to the consumption of these species in traditional Mediterranean communities (Butler 1998; Tardío, Pardo-de- Santayana, and Morales 2006) and their presence in the archaeological record may be the result of their exploitation and consumption by Iberomaurusian populations. *Vicia/Lathyrus* and *Lens* seeds have also been documented in Late Iberomaurusian levels (known as 'Grey Series') at Taforalt (Humphrey et al. 2014), which confirms that these species may have been exploited systematically. In addition, seeds of wild legumes are identified in later Epipalaeolithic and Neolithic contexts at Morocco and other Later

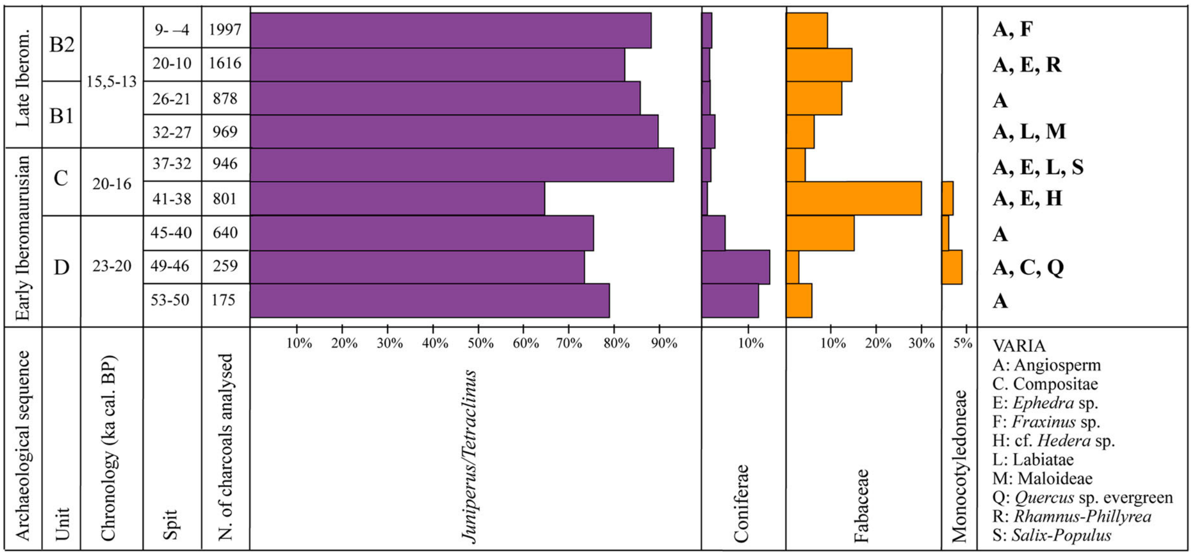

Figure 4. Charcoal diagram of Ifri El Baroud.

Stone Age sites of North Africa, suggesting a continuity in their exploitation (Ballouche and Marinval 2003; Morales In press). In this regard, we should stress the prevalence of caries documented among the human remains found in Late Iberomaurusian levels at Taforalt, showing the great importance of carbohydrate-rich foods in the human diet during this period (Humphrey et al. 2014). This pattern of high prevalence of caries have been also documented in individuals buried in other Iberomaurusian and Capsian (Epipalaeolithic) cemeteries at North Africa, confirming that plant food consumption was common among those communities (De Groote et al., In press).

In short, the exploitation of forest resources at Ifri El Baroud was based on juniper/araar plant formations throughout the sequence, showing great continuity in terms of the presence of woody remains. Firewood collection would undoubtedly have had a cultural bias, but it reflects the species present in the environment around the cave, although it is possible that there were other species that have not been recorded. This continuity does not seem to reflect the environmental and sedimentary shift that led to the transition between the Early Iberomaurusian (Units D and C) levels and the Late Iberomaurusian 'Escargotière' (Unit B), which took place during the transition from Heinrich event 1 to Greenland Interstadial 1 (*ca.* 16–15 ka cal BP) (Dansgaard, White, and Johnsen 1989; Fletcher et al. 2010; Fletcher and Sánchez Goñi 2008; Rasmussen et al. 2014). According to our results, we can suggest a great continuity in firewood gathering strategies without reflecting significant changes in the composition of plant formations.

The only fluctuations observed in the anthracological record are those of the leguminous plant curve, which shows two moments of greater frequency: one isolated point at the end of the LGM and another throughout the sequence of the 'Escargotière'. This second moment coincides with a more systematic use of legumes in terms of both their wood and their seeds, which may have been caused by a diversification of these species in the shrub stratum and/or greater availability of these plants in the vicinity of the cave. In the same way, the higher presence of Monocotyledons in Units C and D, could be reflecting a more systematic use of herbaceous plants for other uses (basketry, ropes, vegetable fibers …) (M'Handi and Anderson 2013). Thus, these little fluctuations recorded could be responses to climatic events, but also to the influence of firewood selection criteria and changes in subsistence strategies, as it has been documented in the 'Escargotière' phase.

Correlation Between Landscape Dynamics and Climate Events

The Quaternary Period is characterised by marked climatic variability (Fletcher et al. 2010; Harrison and Sánchez Goñi 2010; Heinrich 1988; Rasmussen et al. 2014; Sánchez Goñi et al. 1999). The most extreme climatic events are known as Heinrich events (HEs), which generate cold, arid periods that reach beyond the latitudes of the Northern Hemisphere (Dansgaard, White, and Johnsen 1989; Heinrich 1988; Kageyama et al. 2005). These global climate changes have led to controversy regarding their impact on the plant landscape and, specifically, the rate at which vegetation responds to climatic oscillations (Andersen et al. 2004; Dansgaard, White, and Johnsen 1989; Kageyama et al. 2005; Kukla et al. 2002; Levis, Foley, and Pollard 1999; Webb et al. 1997).

The chronological sequence of Ifri El Baroud includes several such events. However, the first environmental consideration we can make is the continuity in the presence of formations dominated by *Juniperus*/*Tetraclinis* throughout the whole sequence, since these were the mostly exploited woody taxa during the occupation, thus suggesting the lasting presence of mostly arid, heliophilous open formations that would have adapted well to poor soil. The climatic events that occurred during the chronological framework of the site could have affected the density of the forest and/or the composition of the understory, but they did not have enough intensity to produce substantial changes in the vegetation. In spite of the considerable homogeneity in terms of the presence of plant taxa, certain subtle variations may be noted.

The base of the sequence coincides with the end of the LGM, where very limited taxa are identified and there is a peak in the presence of woody legumes. After this peak of Fabaceae, they return to minimal values but we do observe a certain modest presence of other shrubs from the Lamiaceae or Ericaceae families, which may indicate greater opening of the canopy and/or a greater variety of the undergrowth (Figure 4). The cold, arid conditions resulting from Heinrich Event 1 (Sanchez Goñi and Harrison 2010) did not bring about a significant change in the dominant species in the spectrum. In this respect, the results from various marine surveys in the Alboran Sea suggest a considerable reduction in forest cover with the increase of taxa characteristic of arid and semi-desert environments (*Artemisia*, *Ephedra*, Cupressaceae) and the decrease of Mediterranean pollen forest taxa (Sánchez-Goñi et al. 2008, 2013) (Figure 5). After H1 event, coinciding with Unit B of Ifri El Baroud, another increase in woody legumes and riparian vegetation is observed, which is accompanied by a slight fluctuations in *Juniperus/Tetraclinis*. This subtle change in the anthracological record, although not very important in terms of the composition of the local woody plant landscape, coincides with the milder GI 1 (Rasmussen et al. 2014) and the visible increase in Mediterranean pollen forest taxa (Figure 5).

Although there was no significant modification of the vegetation in terms of taxonomic composition, it is possible that an opening of the woodland canopy and enrichment of the scrub (Fabaceae) could have led the human groups to exploit these plants more at some specific moments, thus combining climatic and cultural causes.

For the chronological period covered (*ca.* 23–13 ka cal BP), there are hardly any data on plant macroremains in the area under study. Only the preliminary results from the sequence of Sector 9 of Taforalt, the top level of which is dated to the early MSA (*ca.* 27 ka cal BP), offers a prelude to the sequence of Ifri El Baroud (Barton et al. 2016). In this sequence, the

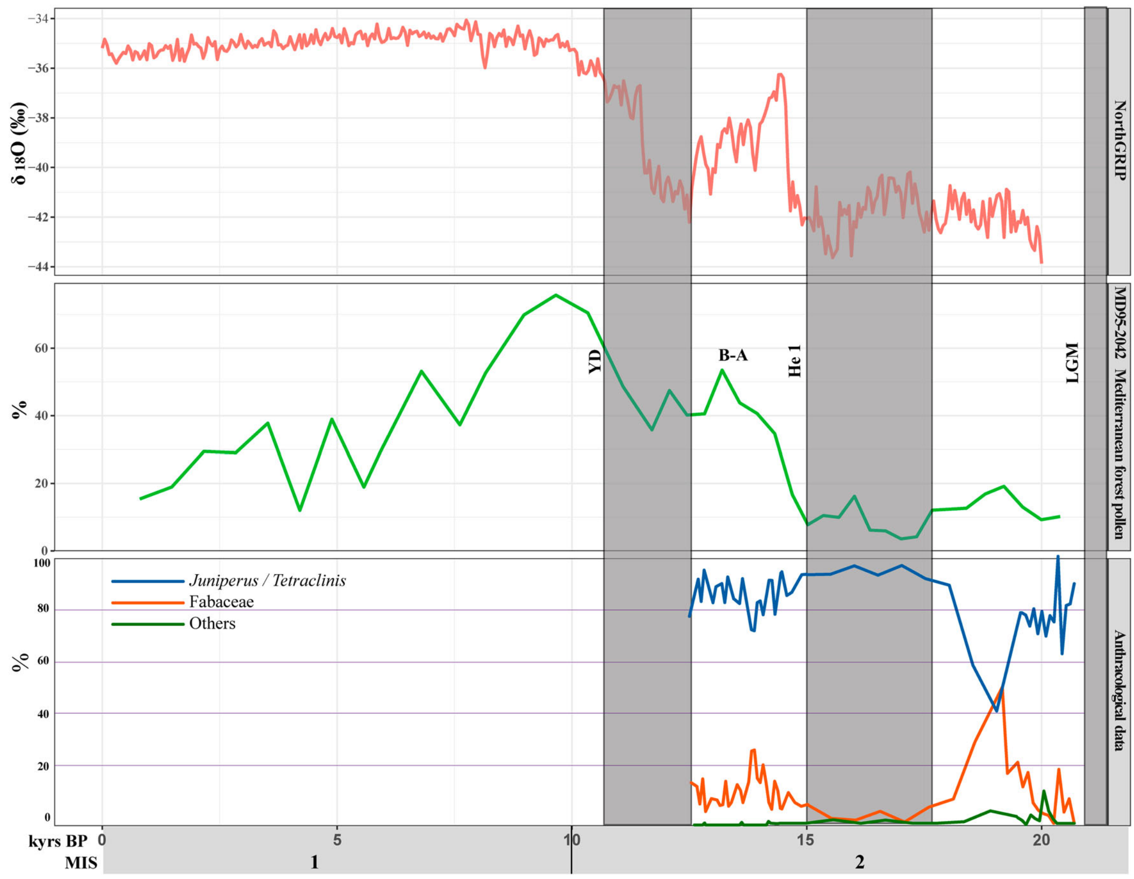

Figure 5. Correlation between charcoal results of Ifri El Baroud, δ ^{18}O from NGRIP ice-core (Andersen et al. 2004; Rasmussen et al. 2014) and Mediterranean forest pollen from Cores SU81-18 and MD95-2042 in the SW Iberian margin (Sánchez-Goñi et al. 2008, 2013).

most abundant taxa identified are *Juniperus*/*Tetraclinis* and, in much smaller percentage, *Quercus* sp. evergreen. Other taxa are occasionally present: trees (*Acer* sp., *Quercus* sp., deciduous), large shrubs (Rosaceae, Maloideae), species found in moist soils (*Salix* sp.) and other shrubs (Cistaceae, Fabaceae and Monocotyledons). The predominance of open coniferous forests at Taforalt is consistent with the regional picture of pre-Holocene sequences, which also includes Ifri El Baroud, although at Taforalt there is a greater component of humidity due to its location 720 m above the sea level.

In a more recent chronology, palaeoenvironmental data from the nearby site of Ifri Oudadane (*ca.* 11–5.7 ka cal BP), situated on the thermo-Mediterranean coast of Morocco, suggest the growth of dense plant cover consisting of evergreen and deciduous oaks (mainly *Quercus coccifera* and *Quercus suber*), *Juniperus/Tetraclinis*, carob trees (*Ceratonia siliqua*), Aleppo pines (*Pinus halepensis*), firs (*Abies pinsapo*) and cedars (*Cedrus atlantica*) (Zapata et al. 2013). These data indicate rapid forestation with thermophilous vegetation during the Holocene, which also seems to be supported by some pollen studies in the area that show the presence of dense woodland cover with evergreen sclerophyllous oaks, Atlantic terebinths (*Pistacia atlantica*), Aleppo pines (*Pinus halepensis*), araar trees (*Tetraclinis articulata*) or Phoenician junipers (*Juniperus phoenicea*), and some carob trees (*Ceratonia siliqua*) along the thermo-Mediterranean belt in 9.9–9.4 ka cal BP (Linstädter, Broich, and Weninger 2018).

The woody vegetation found at Ifri El Baroud is also very similar to that identified in the anthracological analyses corresponding to the Late Glacial period in the Central-Eastern Iberian region, which indicates the existence of certain common regional dynamics for both the northern and southern sides of the Western Mediterranean. Thus, in the anthracological phase CC.1A from Cova de les Cendres (Upper-Late Magdalenian) there is a predominance of cryophilous pines and junipers (Badal and Carrión 2001; Badal García and Martínez Varea 2018), whereas the Late Glacial levels from Ratlla del Bubo (U.E. I–IV) show an increase in aridity based on the abundance of *Juniperus* (Badal and Carrión 2001). These dynamics in the plant landscape were also documented at Santa Maira (Aura et al. 2005), Tossal de la Roca (Uzquiano 1988) and Abric de la Falguera (Carrión Marco 2005), where the junipers and cryophilous pines that dominated until the Epipalaeolithic gave way to the expansion of evergreen and deciduous *Quercus* forests. These sites are concentrated in the current thermo- and meso-Mediterranean belts and the anthracological data for the Late Glacial indicate a lower altitude of the bioclimatic zones, which would apply to Ifri El Baroud during the LGM and part of the Late Glacial.

Conclusions

The analysis of the macrobotanical remains from Ifri El Baroud provides new palaeoenvironmental and palaeoeconomic data for this poorly documented region. The interest of the sequence lies in the shortage of existing data for the period between the LGM and the Late Glacial, given the great sedimentary hiatuses and gaps in the information that affect many sites in the area. The anthracological data from Ifri El Baroud show continuity in the local woody vegetation documented throughout the sequence. The local landscape is therefore characterised by the predominance of juniper/araar together with woody legumes and other very poorly represented taxa. These data reflect the prevalence of a more arid climate than at present, which explains the extent of open heliophilous plant formations. Despite noting subtle alterations in the anthracological sequence (increase in woody legumes at the end of the LGM and after the H1 event – beginning of the Bølling-Allerød period), the continuity in the composition of the woody plant landscape is constant throughout the sequence studied. Therefore, there are no significant variations in firewood collection activities and local woody vegetation dynamics between the Early and Late Iberomaurusian periods. New studies focusing on macrobotanical remains from this region are needed, apart from those already known from Taforalt and Ifri Oudadane, as there are so far no other studied sequences that overlap with that of Ifri El Baroud. Even so, the anthracological data from this site are very similar to the palaeoecological information obtained in Central-Eastern Iberia for the Late Glacial period (i.e. predominance of junipers prior to the establishment of evergreen and deciduous *Quercus* forests). This consistency between the two anthracological spectra suggests the existence of common regional dynamics in the northern and southern parts of the Western Mediterranean.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Funding

This research has been carried out within the framework of the Collaborative Research Centre (CRC) 806 – Our Way to Europe – (Project C2) funded by the German Research Foundation (DFG) and of the Project PALEOPLANT, grant CoG 614960, funded by the European Research Council (ERC), in collaboration with the Institut National des Sciences de l'Archéologie et du Patrimoine. Y. Carrión and J. Morales are beneficiaries of a Ramón y Cajal research fellowship funded by the Spanish Ministerio de Economía, Industria y Competitividad. Part of the charcoal analysis was performed with the financial support of a research technician contract to P. Vidal-Matutano (CPI-16-432) funded by the additional budget from the Ramón y Cajal research programme. P. Vidal-Matutano is funded by the Generalitat Valenciana APOSTD Postdoctoral grant (APOSTD/2017/126).

Notes on contributors

Yolanda Carrión Marco is a Ramón y Cajal Research Fellow at the Department of Prehistory, Archaeology and Ancient History of the University of Valencia, Spain. She specialises in Charcoal Analysis and her research lines deal with woodland exploitation, landscape reconstruction, land use and history of the species. Her recent works include Middle and Upper Palaeolithic charcoal records from Iberian and North African sites. She is a researcher in several projects and principal investigator of a project of the Spanish Ministry about past vegetation dynamics under human impact in the Balearic Islands.

Paloma Vidal-Matutano is a postdoctoral researcher at the Cultures et Environnements Préhistoire, Antiquité, Moyen Âge (CEPAM – UMR 7264), Nice, France, and at the Department of Prehistory, Archaeology and Ancient History (University of Valencia), Valencia, Spain. Her research focuses on charcoal analyses from Middle Palaeolithic sites located in Western and Eastern Europe using experimental tools and spatial distribution software for a palaeoeconomical approach. She is involved in several archaeological projects, including El Salt, Abric del Pastor and Crvena Stijena in Montenegro. She is the author/co-author of several publications with impact factor and book chapters.

Jacob Morales is a Ramón y Cajal Research Fellow at the University of Las Palmas de Gran Canaria, Spain. His research interests include the transition to farming in North Africa, the adaptations of farming to island environments, the role of food plants in the Palaeolithic diet, and more broadly the human–plant interactions.

Pedro Henríquez-Valido is a PhD student at the University of Las Palmas de Gran Canaria, Spain. His research focuses on storage during the pre-Hispanic period of the Canary Islands through the application of archaeoentomology and archaeobotany.

Alessandro Potì is a prehistoric archaeologist specialised in the study of lithic industries. He trained at the Universities of Trento (Italy), Ferrara (Italy), and Cologne (Germany), participating consistently in fieldwork at many sites. His research deals with European and North African Palaeolithic and with Experimental Archaeology.

Martin Kehl is a researcher at the Institute of Geography, Faculty of Mathematics and Natural Science, University of Cologne, who studies soils and sediments as archives of climate change, landscape evolution and human behaviour. As a member of the CRC806 he specialised in micromorphology for elucidating processes of sediment accumulation and post-depositional alteration in caves, rockshelters or open-air sites. He has been collaborating at diverse Middle to Upper Palaeolithic or Neolithic sites in Iberia, Northern Africa, and Central Europe.

Jörg Linstädter is scientific director at German Archaeological Institute, Commission for Archaeology of non-European Cultures and lecturer at Eberhard Karls University, Tübingen, Germany. He is a research associate in the project CRC 806 "Our way to Europe", University of Cologne, Germany, and principal investigator of the Tandem-Project "Environment and Archaeology in Northeast-Morocco" funded by Volkswagen Foundation. His research interests deal with African archaeology, Landscape archaeology, climate and environmental change and its impact on prehistoric societies, transition to food production.

Gerd-Christian Weniger is the Director of the Neanderthal Museum, Adjunct Professor at the Institute for Prehistory at the University of Cologne and author and editor of numerous texts in the fields of Stone Age archaeology and cultural anthropology. He is a member of several international Scientific Boards and Committees.

Abdeslam Mikdad is responsible for two research programmes attached to the Prehistory Department of the National Institute of Archeology and Heritage Sciences. These two programmes concern two vast areas of Morocco, the Eastern Rif and the central Middle Atlas. He specialises in the study of prehistoric populations of the late Pleistocene and Holocene through the analysis of ceramics and lithic. On the assets of Abdeslam Mikdad, several publications devoted to the results of research carried out in different sites of Morocco.

ORCID

Yolanda Carrión Marco http://orcid.org/0000-0003-4064-249X

References

Andersen, K. K., N. Azuma, J.-M. Barnola, M. Bigler, P. Biscaye, N. Caillon, J. Chappellaz, et al. 2004. "High-resolution Record of Northern Hemisphere Climate Extending Into the Last Interglacial Period." *Nature* 431: 147–151. doi: 10.1038/nature02805.

Arranz-Otaegui, A. 2017. "Evaluating the Impact of Water Flotation and the State of the Wood in Archaeological Wood Charcoal Remains: Implications for the Reconstruction of Past Vegetation and Identification of Firewood Gathering Strategies at Tell Qarassa North (South Syria)." *Quaternary International* 457: 60–73. doi:10.1016/j.quaint.2016.06.030.

Aura, E., Y. Carrión, E. Estrelles, and G. Pérez Jordà. 2005. "Plant Economy of Hunter-Gatherer Groups at the End of the Last Ice Age: Plant Macroremains From the Cave of Santa Maira (Alacant, Spain) ca. 12000–9000 b.p." *Vegetation History and Archaeobotany* 14 (4): 542–550. http://www.jstor.org/stable/23419310.

Badal, E., and Y. Carrión. 2001. "Del glaciar al interglaciar: los paisajes vegetales a partir de los restos carbonizados en las cuevas de Alicante." In *De Neandertales a Cromañones. El inicio del poblamiento humano en tierras valencianas*, edited by Valentín Villaverde, 21–40. Valencia: Universitat de València.

Badal, E., and C. Heinz. 1991. "Méthodes utilisées en Anthracologie pour l´étude de sites préhistoriques." In *IInd Deya International Conference of Prehistory: Recent Developments in Western Mediterranean Prehistory: Archaeological Techniques, Technology, and Theory. BAR International Series*. Chap. 573., edited by W. H. Waldren, J. A. Ensenyat, and R. C. Kennard, 17–47. Oxford: Tempus Reparatum.

Badal García, E., and C. Mª. Martínez Varea. 2018. "Different Parts of the Same Plants. Charcoals and Seeds From Cova de les Cendres (Alicante, Spain)." *Quaternary International* 463: 391–400. doi:10.1016/j.quaint.2016.12.020.

Ballouche, A., and P. Marinval. 2003. "Données palynologiques et carpologiques sur la domestication des plantes et l'agriculture dans le Néolithique ancien du Maroc septentrional (site de Kaf Taht El-Ghar)." *Revue d'archéométrie* 27: 49–54. doi:10.3406/arsci.2003.1041.

Barathon, J.-J., H. El Abassi, C. Lechevalier, F. Malek, and M.-C. Jolly-Saad. 2000. "Mise au point sur les formations holocènes dans le Rif oriental (Maroc) / A Chronology of Holocene deposits in the Eastern Rif Mountains (Morocco)." *Géomorphologie : Relief, Processus, Environnement* 6: 221–238.

Barton, R. N. E., and A. Bouzouggar. 2013. "Hunter-Gatherers of the Maghreb 25,000–6,000 Years Ago." In *The Oxford Handbook of African Archaeology*. Vol. 30., edited by Peter Mitchell, and Paul J. Lane, 431–443. Oxford: Oxford University Press.

Barton, R. N. E., A. Bouzouggar, S. N. Collcutt, R. Gale, T. F. G. Higham, L. Humphrey, S. Parfitt, E. Rhodes, C. Stringer, and F. Malek. 2005. "The Late Upper Palaeolithic Occupation of the Moroccan Northwest Maghreb During the Last Glacial Maximum." *African Archaeological Review* 22 (2): 77–100. doi:10.1007/s10437-005-4190-yDO.

Barton, R. N. E., A. Bouzouggar, J. T. Hogue, S. Lee, S. N. Collcutt, and P. Ditchfield. 2013. "Origins of the Iberomaurusian in NW Africa: New AMS Radiocarbon Dating of the Middle and Later Stone Age Deposits at Taforalt Cave, Morocco." *Journal of Human Evolution* 65 (3): 266–281. doi:10.1016/j.jhevol.2013.06.003.

Barton, R. N. E., S. N. Collcutt, Y. Carrión Marco, L. Clark-Balzan, N. D. Debenham, J. Morales-Mateos, and A. Bouzouggar. 2016. "Reconsidering the MSA to LSA Transition at Taforalt Cave (Morocco) in the Light of New Multi-Proxy Dating Evidence." *Quaternary International* 413: 36–49. doi:10.1016/j.quaint.2015.11.085.

Ben-Ncer, A. 2004. "Étude de la sépulture ibéromaurusienne 1 d'Ifri n'Baroud (Rif oriental, MAROC)." *Antropo* 7: 177–185.

Bouzouggar, A., R. N. E. Barton, S. Blockley, C. Bronk-Ramsey, S. N. Collcutt, R. Gale, T. F. G. Higham, et al. 2008. "Reevaluating the Age of the Iberomaurusian in Morocco." *African Archaeological Review* 25 (1-2): 3–19. https://www.jstor.org/stable/40389413.

Butler, A. 1998. "Grain Legumes: Evidence of These Important Ancient Food Resources From Early Pre-Agrarian and Agrarian Sites in Southwest Asia." In *The Origins of Agriculture and Crop Domestication*, edited by A. B. Damania, J. Valkoun, G. Willcox, and C. O. Qualset, 102–117. Aleppo: ICARDA.

Cacho, I., J. O. Grimalt, C. Pelejero, M. Canals, F. J. Sierro, J. A. Flores, and N. J. Shackleton. 1999. "Dansgaard-Oeschger and Heinrich Event Imprints in Alboran Sea Paleotemperatures." *Paleoceanography* 14 (6): 698–705. doi:10.1029/1999PA900044.

Cacho, I., J. O. Grimalt, F. J. Sierro, N. J. Shackleton, and M. Canals. 2000. "Evidence for Enhanced Mediterranean Thermohaline Circulation During Rapid Climatic Coolings." *Earth and Planetary Science Letters* 183: 417–429. doi:10.1016/S0012-821X(00)00296-X.

Cacho, I., N. J. Shackleton, H. Elderfield, F. J. Sierro, and J. Grimalt. 2006. "Glacial Rapid Variability in Deep-Water Temperature and δ18O From the Western Mediterranean Sea." *Quaternary Science Reviews* 25: 3294–3311. doi:10.1016/j.quascirev.2006.10.004.

Carrión Marco, Y. 2005. *La vegetación mediterránea y atlántica de la península Ibérica. Nuevas secuencias antracológicas*. Trabajos Varios de S.I.P., 104. Diputación de Valencia.

Carrión Marco, Y., J. Morales, M. Portillo, G. Pérez Jordà, L. Peña-Chocarro, and L. Zapata. 2018. "The use of Wild Plants in the Palaeolithic and Neolithic of North-Western Africa: Preliminary Results From the PALEOPLANT Project." In *Plants and People in the African Past: Progress in African Archaeobotany*, edited by A. Mª. Mercuri, C. D'Andrea, R. Fornaciari, and A. Höhn, 146–176. Cham: Springer.

Chabal, L. 1988. "Pourquoi et comment prélever les charbons de bois pour la période antique: les méthodes utilisées sur le site de Lattes (Hérault)." *Lattara* 1: 187–222.

Chabal, L. 1997. *Forêts et sociétés en Languedoc (Néolithique final, Antiquité tardive): l'anthracologie, méthode et paléoécologie*. Éditions de la Maison des sciences de l'homme.

Charco, J. 1999. *El bosque mediterráneo en el norte de África. Biodiversidad y lucha contra la desertificación*. Madrid: Agencia Española de Cooperación Internacional.

Costa, M., C. Morla, and H. Sainz, eds. 2005. *Los bosques ibéricos: Una interpretación geobotánica*. Barcelona: Planeta.

Couvert, M. 1976. "Traduction des éléments de la flore préhistorique en facteurs climatiques." *Libyca* 24: 9–20.

Couvert, M., and J. Roche. 1978. "L'environnement de la grotte de Taforalt durant la fin du Paléolithique et l'Epipaléolithique." *Bull. d'Arch. Marocain Rabat* 11: 1–8.

Dansgaard, W., J. White, and S. Johnsen. 1989. "The Abrupt Termination of the Younger Dryas Climate Event." *Nature* 339: 532–534. doi:10.1038/339532a0.

De Groote, I., J. Morales, and L. Humphrey. In press. "Oral Health in Late Pleistocene and Holocene North West Africa." *Journal of Archaeological Science: Reports*. doi:10.1016/j.jasrep.2018.03.019.

Eiwanger, J. 1992. "Recherches archéologiques dans le Rif oriental: Un projet marocain et allemand". Colloque international: Cent ans de recherchesarchéologiques au Maroc, Rabat.

Eiwanger, J., and A. Mikdad. 1997. "Vorgeschichtliche Forschungen im Rif." *Archäologie in Deutschland* 4: 12–17.

Fletcher, W. J., and M. F. Sánchez Goñi. 2008. "Orbital- and Sub-Orbital-Scale Climate Impacts on Vegetation of the Western Mediterranean Basin Over the Last 48,000 yr." *Quaternary Research* 70 (3): 451–464. doi:10.1016/j.yqres.2008.07.002.

Fletcher, W. J., M. F. Sánchez Goñi, J. R. Allen, R. Cheddadi, N. Combourieu-Nebout, B. Huntley, I. Lawson, et al. 2010. "Millennial-scale Variability During the Last Glacial in Vegetation Records From Europe." *Quaternary Science Reviews* 29: 2839–2864. doi:10.1016/j.quascirev.2009.11.015.

Görsdorf, J., and J. Eiwanger. 1999. "Datations radiocarbone des sites du Paléolithique final, de l'Epipaléolithique et du Néolithique du nord est du Maroc." *Mémoires de la Société préhistorique française* 26: 365–369.

Greguss, P. 1955. *Identification of Living Gymnosperms on the Basis of Xylotomy*. Budapest: Akadémiai Kiado.

Greguss, P. 1959. *Holzanatomie der Europaïschen Laubhölzer und Straücher*. Budapest: Akadémiai Kiado.

Harrison, S., and M. F. Sánchez Goñi. 2010. "Global Patterns of Vegetation Response to Millennial-Scale Variability and Rapid Climate Change During the Last Glacial Period." *Quaternary Science Reviews* 29: 2957–2980. doi:10.1016/j.quascirev.2010.07.016.

Heinrich, H. 1988. "Origin and Consequences of Cyclic ice Rafting in the Northeast Atlantic Ocean During the Past 130,000 Years." *Quaternary Research* 29: 142–152. doi:10.1016/0033-5894(88)90057-9.

Henry, A., and I. Théry-Parisot. 2014. "From Evenk Campfires to Prehistoric Hearths: Charcoal Analysis as a Tool for Identifying the Use of Rotten Wood as Fuel." *Journal of Archaeological Science* 52: 321–336. doi:10.1016/j.jas.2014.09.005.

Humphrey, L., I. De Groote, J. Morales, N. Barton, S. Collcutt, C. B. Ramsey, and A. Bouzouggar. 2014. "Earliest Evidence for Caries and Exploitation of Starchy Plant Foods in Pleistocene Hunter-gatherers from Morocco." *Proceedings of the National Academy of Sciences* 111 (3): 954–959. doi:10.1073/pnas.1318176111.

Jacquiot, C. 1955. *Atlas d´anatomie des bois des conifères*. Paris: Cent. Tech. Bois.

Jacquiot, C., D. Trenard, and D. Dirol. 1973. *Atlas d´anatomie des bois des angiospermes (Essences feuillues)*. Paris: Cent. Tech. Bois.

Kageyama, M., N. C. Nebout, P. Sepulchre, O. Peyron, G. Krinner, G. Ramstein, and J.-P. Cazet. 2005. "The Last Glacial Maximum and Heinrich Event 1 in Terms of Climate and Vegetation Around the Alboran Sea: A Preliminary Model-Data Comparison." *Comptes Rendus Geoscience* 337: 983–992. doi:10.1016/j.crte.2005.04.012.

Kukla, G. J., M. L. Bender, J.-L. de Beaulieu, G. Bond, W. S. Broecker, P. Cleveringa, J. E. Gavin, et al. 2002. "Last Interglacial Climates." *Quaternary Research* 58: 2–13. doi:10.1006/qres.2001.2316.

Levis, S., J. A. Foley, and D. Pollard. 1999. "CO^2, Climate, and Vegetation Feedbacks at the Last Glacial Maximum." *Journal of Geophysical Research: Atmospheres* 104: 31191–31198. doi:10.1029/1999JD900837.

Linstädter, J. 2011. "The Epipalaeolithic–Neolithic Transition in the Eastern Rif Mountains and the Lower Moulouya Valley, Morocco." In *Os últimos caçadores-recolectores e as primeiras comunidades productoras do sul da Península Ibérica e do norte de Marrocos*, edited by J. F. Gibaja, and A. F. Carvalho, 89–98. Faro: Universidade do Algarve. Promontoria Monográfica.

Linstädter, J., M. Broich, and B. Weninger. 2018. "Defining the Early Neolithic of the Eastern Rif, Morocco – Spatial Distribution, Chronological Framework and Impact of Environmental Changes." *Quaternary International* 472 (B): 272–282. doi:10.1016/j.quaint.2016.07.042.

Linstädter, J., J. Eiwanger, A. Mikdad, and G. Weniger. 2012. "Human Occupation of Northwest Africa: A Review of Middle Palaeolithic to Epipalaeolithic Sites in Morocco." *Quaternary International* 274: 158–174. doi:10.1016/j.quaint.2012.02.017.

Linstädter, J., M. Kehl, M. Broich, and J. A. López-Sáez. 2016. "Chronostratigraphy, Site Formation Processes and Pollen Record of Ifri n'Etsedda, NE Morocco." *Quaternary International* 410 (A): 6–29. doi:10.1016/j.quaint.2015.11.017.

M'Handi, M., and P. Anderson. 2013. "Approche ethnoarchéologique d'outils et techniques de moisson de l'alfa (Stipa tenacissima) dans la région des Hautes Steppes en Tunisie: Premières observations et analyses." In *Regards croisés sur les outils liés au travail des végétaux. An interdisciplinary focus on plant working tools. 23 rencontres internationales d'archéologie et d'histoire d'Antibes*, edited by P. C. Anderson, C. Cheval, and A. Durand, 75–88. Ville d'Antibes: Éditions APDCA.

Mikdad, A., and J. Eiwanger. 2000. "Recherches préhistoriques et protohistoriquesdans le Rif oriental (Maroc). Rapport préliminaire." *Beiträge zur Allgemeinen und Vergleichenden Archäologie* 20: 109–167.

Morales, J. In press. "The Contribution of Botanical Macro-Remains to the Study of Wild Plant Consumption During the Later Stone Age and the Neolithic of North-Western Africa." *Journal of Archaeological Science: Reports*. doi:10.1016/j.jasrep.2018.06.026.

Moreno, A., I. Cacho, M. Canals, J. O. Grimalt, M. F. Sánchez Goñi, N. J. Shackleton, and F. J. Sierro. 2005. "Links Between Marine and Atmospheric Processes Oscillating on a Millennial Time-Scale. A Multi-Proxy Study of the Last 50,000yr From the Alboran Sea (Western Mediterranean Sea)." *Quaternary Science Reviews* 24: 1623–1636. doi:10.1016/j.quascirev.2004.06.018.

Moser, J. 2003. *"La grotte d'Ifri n'Ammar" Tome 1: l'Ibéromaurusien. Forschungen zur Allgemeinen und Vergleichenden Archäologie 8*. Köln: Linden Sof.

Mouhsine, T. 1998. *Etude paléontologique de la faune de la grotte Ifri el Baroud (Rif oriental). Contribution à la connaissance de la paléthnographie, lapaléoécologie et la biogéographie*. Rabat: Mémoire pour l'obtention du Certificat des Etudes Supérieures, INSAP.

Nami, M. 2002. *La séquence Iberomaurisienne d'Ifri El Baroud: sa place dans le Paléolothique supérieur marocain*. Rabat: Ed. Institute National des Sciences de l'Archéologie et du Patrimoine.

Nami, M. 2007. "Les Techno-Complexes Ibéromaurusiens D'Ifri El Baroud (Rif Oriental, Maroc)." *Zeitschrift für Archäologie Außereuropäischer Kulturen* 2: 183–239.

Neumann, K., W. Schoch, P. Détienne, F. H. Schweingruber, and H. Richter. 2001. *Woods of the Sahara and the Sahel*. Bern: Haupt.

Potì, A. 2017. "Technical Change and Environmental Change in the Iberomaurusian. A Case Study from Ifri El Baroud, Morocco." Unpublished PhD diss., University of Cologne.

Quézel, P. 1978. "Analysis of the Flora of Mediterranean and Saharan Africa." *Annals of the Missouri Botanical Garden* 65: 479–534. https://www.jstor.org/stable/2398860.

Rasmussen, S. O., M. Bigler, S. P. Blockley, T. Blunier, S. L. Buchardt, H. B. Clausen, I. Cvijanovic, et al. 2014. "A Stratigraphic Framework for Abrupt Climatic Changes During the Last Glacial Period Based on Three Synchronized Greenland Ice-Core Records: Refining and Extending the INTIMATE Event Stratigraphy." *Quaternary Science Reviews* 106: 14–28. doi:10.1016/j.quascirev.2014.09.007.

Richter, D., J. Moser, M. Nami, J. Eiwanger, and A. Mikdad. 2010. "New Chronometric Data From Ifri n'Ammar (Morocco) and the Chronostratigraphy of the Middle Palaeolithic in the Western Maghreb." *Journal of Human Evolution* 59 (6): 672–679. doi:10.1016/j.jhevol.2010.07.024.

Rivas-Martínez, S. 1987. *Memoria del mapa de series de vegetación de España. 1:400.000*. Madrid: I.C.O.N.A.

Sánchez-Goñi, M. F., E. Bard, A. Landais, L. Rossignol, and F. d'Errico. 2013. "Air–Sea Temperature Decoupling in Western Europe During the Last Interglacial–Glacial Transition." *Nature Geoscience* 6: 837–841. doi:10.1038/ngeo1924.

Sánchez Goñi, M. F., I. Cacho, J. L. Turon, J. Guiot, F. J. Sierro, J. P. Peypouquet, J. O. Grimalt, and N. J. Shackleton. 2002. "Synchroneity Between Marine and Terrestrial Responses to Millennial Scale Climatic Variability During the Last Glacial Period in the

Mediterranean Region." *Climate Dynamics* 19 (1): 95–105. doi:10.1007/s00382-001-0212-x.

Sánchez Goñi, M. F., F. Eynaud, J. Turon, and N. J. Shackleton. 1999. "High Resolution Palynological Record off the Iberian Margin: Direct Land-Sea Correlation for the Last Interglacial Complex." *Earth and Planetary Science Letters* 171: 123–137. doi:10.1016/S0012-821X(99)00141-7.

Sanchez Goñi, M. F., and S. P. Harrison. 2010. "Millennial-Scale Climate Variability and Vegetation Changes During the Last Glacial: Concepts and Terminology." *Quaternary Science Reviews* 29: 2823–2827. doi:10.1016/j.quascirev.2009.11.014.

Sánchez-Goñi, M. F., A. Landais, W. J. Fletcher, F. Naughton, S. Desprat, and J. Duprat. 2008. "Contrasting Impacts of Dansgaard–Oeschger Events Over a Western European Latitudinal Transect Modulated by Orbital Parameters." *Quaternary Science Reviews* 27: 1136–1151. doi:10.1016/j.quascirev.2008.03.003.

Schweingruber, F. H. 1976. *Mikroskopische holzanatomic, Anatomie microscopique de bois*. Birmensdorf: Institut féderal de recherches forestière, Zurcher AG.

Schweingruber, F. H. 1990. *Anatomie europäischer Hölzer*. Bern: Haupt.

Tardío, J., M. Pardo-de- Santayana, and R. Morales. 2006. "Ethnobotanical Review of Wild Edible Plants in Spain." *Botanical Journal of the Linnean Society* 152: 27–71. doi:10.1111/j.1095-8339.2006.00549.x.

Tutin, T. G., V. H. Heywood, N. A. Burgues, D. H. Valentine, S. M. Walters, and D. A. Webb. 1964. *Flora Europaea*. Cambridge: Cambridge University Press.

Uzquiano, P. 1988. "Analyse anthracologique du Tossal de la Roca (Paléolithique Supérieur Final Epipaléolithique, Province d'Alicante, Espagne)." *PACT* 22-IV.1: 209–217.

Vernet, J.-L., E. Bazile, and J. Evin. 1979. "Coordination des analyses anthracologiques et des datations absolues sur charbons de bois." *Bulletin de la Société Préhistorique Française* 76 (3): 76–79. doi:10.3406/bspf.1979.5185.

Vidal-Matutano, P., C. M. Hernández, B. Galván, and C. Mallol. 2015. "Neanderthal Firewood Management: Evidence From Stratigraphic Unit IV of Abric del Pastor (Eastern Iberia)." *Quaternary Science Reviews* 111: 81–93. doi:10.1016/j.quascirev.2015.01.010.

Ward, S. 2007. "Reconstructing Late Pleistocene Vegetation Dynamics from Archaeological Cave Sites in the Western Mediterranean: Links with Climate and Cultural Changes." PhD diss., University of Oxford.

Webb, R. S., D. H. Rind, S. J. Lehman, R. J. Healy, and D. Sigman. 1997. "Influence of Ocean Heat Transport on the Climate of the Last Glacial Maximum." *Nature* 385: 695–699. doi:10.1038/385695a0.

Wengler, L., and J. L. Vernet. 1992. "Vegetation, Sedimentary Deposits and Climates during the Late Pleistocene and Holocene in Eastern Morocco." *Palaeogeography, Palaeoclimatology, Palaeoecology* 94 (1–4): 141–167. doi:10.1016/0031-0182(92)90117-N.

Zapata, L., J. A. López Sáez, M. Ruiz-Alonso, J. Linstädter, G. Pérez-Jordà, J. Morales, M. Kehl, and L. Peña-Chocarro. 2013. "Holocene Environmental Change and Human Impact in NE Morocco: Palaeobotanical Evidence From Ifri Oudadane." *The Holocene* 23 (9): 1286–1296. doi:10.1177/0959683613486944.