Hassi Berkane and Late Iberomaurusian Land Use in the Eastern Rif, Morocco

Hassi Berkane und die Landnutzung im späten Ibéromaurusien im östlichen Rif, Marokko

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Abstract - Previous studies have shown that climate events have the potential to significantly impact hunter-gatherer land use patterns in the Western Mediterranean. Especially Heinrich Event 1 (18-15.6 ka calBP) affected the long-term stability of Magdalenian groups on the South of the Iberian Peninsula, while it did not impact the contemporaneous Iberomaurusian groups in Morocco to the same degree. It remains unclear which role the mass exploitation of land snails, beginning in Greenland Interstadial 1 (from ca. 15.6 ka calBP), played in the establishment of these land use patterns. To examine this further, studies on a regional scale are needed.

Survey projects in the Eastern Rif of Morocco led to the discovery of multiple new Late Iberomaurusan sites, one of these being Hassi Berkane, discovered in 2013 and surveyed intensively in 2014. This paper presents the results of these works and ties Hassi Berkane into the Late Iberomaurusian landscape of the Eastern Rif. Together with other sites, such as Ifri el Baroud and Ifri n'Ammar, we were able to analyze settlement orientation and mobility patterns. These show that the Late Iberomaurusian groups chose site locations mainly based on fresh water sources and were mobile in daily activities, but not particularly mobile outside of ranges accessible in a day's walk. This impression of a fairly immobile society can be linked to previous land use models which point to considerable settlement stability for Moroccan hunter-gatherers during GI1 and the Younger Dryas (ca. 15-11.7 ka calBP).

Zusammenfassung - *Das Spätglazial im westlichen Mittelmeergebiet ist durch starke Klimaschwankungen sowie Schwankungen in der Populationsdichte und damit verbundenen Änderungen der Siedlungssysteme gekennzeichnet. Im Süden der Iberischen Halbinsel hatte vor allem das Heinrich Event 1 negativen Einfluss auf die Landnutzungsmuster der paläolithischen Gemeinschaften, während die zeitgleichen Jäger-Sammler-Gruppen in Marokko davon weitgehend unberührt blieben. In der vorliegenden regionalen Studie werden Landnutzungs- und Mobilitätsstrategien des Späten Ibéromaurusien in Nordostmarokko untersucht. Ausgangspunkt ist die Entdeckung der Fundstelle Hassi Berkane mit Siedlungsspuren vom Jungpaläolithikum bis zum Neolithikum.*

Das Felsschutzdach Hassi Berkane liegt östlich des gleichnamigen Dorfes im marokkanischen Rif auf einem Hang oberhalb eines ehemaligen spanischen Forts aus dem Beginn des 20. Jahrhunderts (Abb. 2). Zwischen Fort und Felsschutzdach befindet sich eine Süßwasserquelle, die das Zentrum der Fundstelle bildet. In Gräben um das Fort waren bereits bei der Entdeckung der Fundstelle Siedlungsschichten sichtbar. Dabei handelt es sich um Reste einer „Escargotière", die durch große Mengen terrestrischer Schneckenschalen, Steinwerkzeuge und Aschenlagen charakterisiert ist. Aufgrund der Begehung kann die gesamte Siedlungsfläche auf ca. 2 000 m² geschätzt werden, mit der Quelle im Zentrum. Die offenen Gräben wurden 2014 an mehreren Stellen gesäubert und es wurden zwei Bohrungen durchgeführt (Abb. 3). Aus den Bohrkernen und einem der Profile wurden Sinter- und ^{14}C-Proben entnommen. Die radiometrischen Datierungen stellen die Besiedlung in das Späte Ibéromaurusien, das Epipaläolithikum und das Späte Neolithikum (Abb. 4). Unter dem Humushorizont a liegt das mehrfach gegliederte Sediment der Escargotière, das sich in die Schichten b (z.B. b1/2), c, d und e gliedert. Die Sequenz wird durch den anstehenden Hangschutt f abgeschlossen. Artefakte stammen vorwiegend aus dem Schichtkomplex b sowie aus der Schicht f.

Insgesamt wurden aus den Bohrkernen, dem Profil OW-W sowie von der Oberfläche 314 Funde geborgen; hiervon sind 224 Steinartefakte, 68 unbestimmbare Tierknochen und 16 Fragmente von Straußeneischalen. Sechs Keramikscherben von der Oberfläche stammen wahrscheinlich von der modernen Nutzung des Platzes. Das meiste Material stammt aus Schicht b der Escargotière; nur wenige undiagnostische Artefakte stammen aus der Basisschicht f. Die Artefakte von der Oberfläche können keiner der drei Siedlungsphasen eindeutig zugeordnet werden. Lithische Rohmaterialien wurden vorwiegend aus Schottern der Moulouya in ca. 10 km Entfernung gesammelt. Nur ein Artefakt stammt womöglich von der etwa 64 km entfernten Rohmaterialquelle Ain Zora. Ein menschlicher Zahn wurde ohne sicheren stratigraphischen Zusammenhang geborgen (Abb. 7).

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Hassi Berkane gehört zu einer Serie von Fundplätzen mit Inventaren des späten Ibéromaurusien wie Ifri el Baorud, Ifri n'Ammar, Hassi Ouenzga plein air und Ifri Armas. Die Verteilung der Fundstellen wurde mit Kerndichteschätzungen untersucht und ihre Einzugsgebiete mit der Site Catchment Analyse. Die Einzugsgebiete gliedern sich in ein tägliches Schweifgebiet (daily range), das innerhalb eines Tages genutzt werden kann, und in ein Rohmaterialbeschaffungsgebiet (procurement range). Die Kerndichteschätzung zeigt keine klaren Fundstellencluster, sondern eine eher gleichmäßige Verteilung über die Landschaft (Abb. 8). Gemäß der Analyse der täglichen Einzugsgebiete orientierte sich die Lage der Fundstellen stärker an Süßwasserquellen orientierte als an den lithischen Rohmaterialquellen. Allerdings liegen letztere im täglichen Schweifgebiet oder nur knapp darüber (Abb. 11). Dies deutet darauf hin, dass die Gruppen vor allem in ihren täglichen Bewegungen recht mobil waren, über die täglichen Schweifgebiete hinaus aber nur eine geringe Mobilität erkennen lassen. Sie bewegten sich lediglich in einem kleinen Gebiet innerhalb des östlichen Rifs (Abb. 13). Dieser Trend zu hoher lokaler Mobilität bei gleichzeitig geringer regionaler oder überregionaler Mobilität kann als Indiz für günstige Habitatbedingungen verstanden werden und unterstützt damit Ergebnisse früherer Arbeiten aus der Region.

Keywords - Iberomaurusian, Morocco, Land use, GIS, Heinrich Event 1
Ibéromaurusien, Marokko, Landnutzung, GIS, Heinrich Event 1

Introduction

The Late Glacial in the westernmost Mediterranean is marked by strong fluctuations in climate, population densities and land use strategies (Barton et al. 2018; Weniger et al. 2019). These fluctuations are inherently linked, climate having the potential to significantly influence hunter-gatherer behavior (Stein Mandryk 1993). Especially Heinrich Event 1 (HE1) (18-15.6 ka calBP) (Sánchez Goñi & Harrison 2010) impacted site distribution, site numbers and social networks in the Western Mediterranean, especially in the South of the Iberian Peninsula (Weniger et al. 2019). This climate event did not have the same effect on the contemporaneous neighbors in Morocco, however; the Late Glacial groups here show signs of settlement stability throughout the period of extreme climate fluctuations between HE1 and the Younger Dryas (YD) (18-11.7 ka calBP) (Weniger et al. 2019). The approach in Weniger et al. (2019) focused on examining supra-regional trends in Palaeolithic settlement systems; until now, regional analyses are rare (Barton et al. 2018). Such studies have the potential to identify more local developments and allow us to incorporate additional, site-specific data and identify new patterns. In this paper, we focus on a small region in Northeastern Morocco, the Eastern Rif (Fig. 1), and present Late Iberomaurusian sites dated to Greenland Interstadial 1 (GI1) and the Younger Dryas (ca. 15-11.7 calBP, following Rasmussen et al. 2014). Recent studies in the region led to the discovery of a new site, Hassi Berkane, which will be presented first. This new site adds to the archaeological record of the Late Iberomaurusian and gives us new data with which we can analyze land use on a regional scale.

The Iberomaurusian in the Eastern Rif (Morocco)

The Upper Palaeolithic of Morocco is described as the Iberomaurusian. Sites from this techno-complex share a lithic industry that is is based on microlithic backed bladelets and points, which often make up the bulk of the assemblages (Bouzouggar et al. 2008; Potì 2017). Many instances of burials, traces of pigment use, ornaments, and few examples of rock and mobile art attest to a particularly rich Late Iberomaurusian culture (Moser 2003; Nami 2007; Bouzouggar et al. 2008; Mariotti et al. 2009, Olszewski et al. 2011; Potì 2017). Especially the subsistence spectrum is interesting: the Iberomaurusian groups hunted different species of large herbivores (among others large quantities of barbary sheep) (Potì 2017) and collected wild plants (Humphrey et al. 2014), but also consumed large quantities of edible terrestrial snails and left their shells behind, forming often massive shell middens (*escargotières*) in the sites (Lubbel 2004; Hutterer et al. 2011; Linstädter 2014). Such sites are spread along North Africa, from the Atlantic coast of Morocco to the northeastern Littoral of Libya. Although the sites concentrate on the coastal regions, they are also found farther inland (Potì 2017). The earliest evidence of the Iberomaurusian was identified in Tamar Hat, in Algeria, dating to ca. 25 ka calBP (Hogue & Barton 2016). In Morocco, first evidences are slightly younger. The techno-complex can be divided into two phases, an Early Iberomaurusian, dating to Greenland Stadials 2.1a-b-c (ca. 23-15 ka calBP), and a Late Iberomaurusian, corresponding to Greenland Interstadial 1 and the Younger Dryas (ca. 15-11.7 ka calBP) (Linstädter et al. 2012a; Potì et al. 2019a; Potì et al. 2019b; Weniger et al. 2019). Traces from the earlier phase are rare in the Maghreb, and only represented by few sites, such as Ifri el Baroud (Potì et al. 2019b) and Taforalt (Barton et al. 2013). More sites are known from the later phase, where we also see an increase in settlement activity and the aforementioned regular formation of shell middens comprised of terrestrial molluscs (Taylor et al. 2011; Linstädter et al. 2012a; Weniger et al. 2019). The Iberomaurusian ends with the end of the Pleistocene, transitioning into the Holocene Epipalaeolithic (Linstädter et al. 2012a).

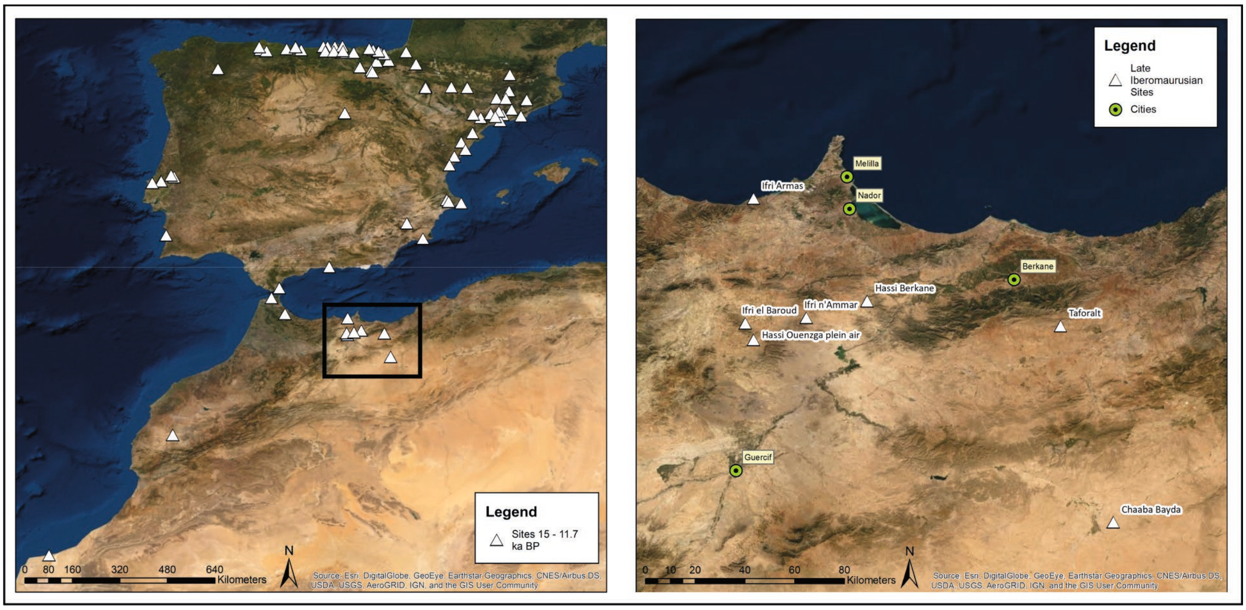

Fig. 1. Palaeolithic sites in the westernmost Mediterranean (Iberian Peninsula and Morocco) dated to Greenland Interstadial 1 (GI1) and Greenland Stadial 1 (GS1) (15-11.7 ka calBP).

Abb. 1. *Paläolithische Fundstellen im Westlichsten Mittelmeerraum (Marokko, Spanien, Portugal) aus dem Grönland Interstadial 1 (GI1) und Grönland Stadial 1 (GS1) (15-11.7 ka calBP).*

Until now, it is still unclear how the exploitation of land snails influenced the mobility and settlement pattern of the Late Iberomaurusian hunter-gatherers. A simple assumption would be that we can identify a link between the mobility patterns of a society and the mobility level of an important faunal resource (Linstädter 2014). This must, however, be examined in detail. To shed light on this issue, we must first characterize the mobility and settlement patterns of Late Iberomaurusian groups in the Maghreb.

The Eastern Rif in Morocco was the focus of a 20-year long fieldwork and survey campaign, conducted by the University of Cologne within the framework of the CRC 806 – "*Our way to Europe*", the *Kommission für die Archäologie Außereuropäischer Kulturen* (KAAK) of the German Archaeological Institute (DAI), and the *Institut National des Sciences de l'Archéologie et du Patrimoine* (INSAP), which had begun in 1995 (Mikdad & Eiwanger 2000). This project led to the discovery of over one hundred sites from the Pleistocene to the Holocene including several Late Iberomaurusian sites: Ifri n'Ammar (Moser 2003), Ifri Armas (Lorenz 2010), Hassi Ouenzga plein air (Linstädter et al. 2012a), Ifri el Baroud (Potì et al. 2019a), and finally Hassi Berkane, all in the direct neighborhood of previously discovered contemporaneous sites Chaaba Bayda (Wengler & Vernet 1992) and Taforalt (Barton et al. 2013). The newly described site, Hassi Berkane, was discovered in 2013 during surveying and revisited in 2014 and 2015 for detailed prospection; results from these analyses will be presented in this paper.

Ifri el Baroud was excavated in 1995–1996 and again in 2015 (Potì et al. 2019b). The sequence spans the Early as well as the Late Iberomaurusian (22.7-12.9 ka calBP), and documents the sedimentological transition from fine-grained, sandy cave sediments of the early phase (layers C and D) to the shell midden of the later phase (layers B1 and B2), the latter of which corresponds to Greenland Interstadial 1. The sequence and lithic material from this site is presented in detail in Potì (2017) and Potì et al. (2019a, b). The authors could document a shift in technology from the Early to the Late Iberomaurusian along with a change of the raw material procurement strategy (Potì et al. 2019b).

The neighboring site Ifri n'Ammar has yielded a particularly long stratigraphical sequence, spanning into the Middle Palaeolithic. In addition to a substantial lithic collection, presented and analyzed (Moser 2003), multiple human burials and other facets of a particularly rich culture were identified from the Late Iberomaurusian layers, which also broadly date to Greenland Interstadial 1. The shell midden in Hassi Ouenzga plein air can be attributed to the same time frame. This site is located in the direct vicinity of the Epipalaeolithic and Neolithic site Hassi Ouenzga abri (Linstädter 2004); the assemblage and stratigraphy were analyzed by Jörg Holzkämper as part of a research stipend from the German Archaeological Institute (DAI) (J. Holzkämper, unpubl. data).

The final site from the region, Ifri Armas, is also better known for its younger material from the Epipalaeolithic and Neolithic (Lorenz 2010). However, a directly dated human bone along with other radiometrically dated material adds it to the list of Late Iberomaurusian sites of the Eastern Rif. Unfortunately, the stratigraphy of this site is highly mixed, and, although the dates show human presence during Greenland Interstadial 1 and the Younger Dryas, we cannot be sure of the nature of the site's use as no intact Late Iberomaurusian assemblage could be singled out from the material.

Each of these sites yielded radiometric ages which calibrate to the time frame between 15 and 11.7 ka calBP, a microlithic, bladelet-based lithic industry, and ashy, snail-shell rich sediments. These cultural and chronological similarities allow the grouping of all of these sites into one Late Iberomaurisian techno-complex, for which we assume broad cultural similarities. Although individual local and temporal fluctuations need to be accounted for and may not be represented in the following analyses, we think it appropriate to group these sites together in order to contextualize them in the landscape and obtain first estimates of Late Iberomaurusian land use behavior.

The goal of this paper is to characterize mobility and settlement pattern for the Late Iberomaurusian, as a prerequisite for the discussion on the role of terrestrial molluscs in the hunter-gatherer subsistence spectrum. We therefore focus on the small region in Northwestern Morocco with data from sites obtained during the course of one long-term research project, allowing a certain degree of comparability between the site archives. We aim to provide a first sketch of possible regional land use, settlement and mobility behavioral patterns which can be used as a basis for further analyses.

Methods

We applied a number of methodological approaches to analyzing land use and mobility patterns of the Late Iberomaurusian in the Eastern Rif. To integrate Hassi Berkane into the setting of Late Iberomaususian sites we carried out special field work and lab analyses. During the survey we cleaned open profiles in multiple areas, took two sediment drill cores, and collected artifacts from the surface of the whole settlement area. The statigraphy of the drill cores was described in detail and, when possible, Munsell sediment soil color codes were given (Munsell 2000). From the drill cores and the profiles, organic material and flowstone samples were taken in order to determine the chronology of the site.

The typology and technology of the lithic assemblages was described following Tixier 1963 and raw material was classified macroscopically based on samples and references in Linstädter & Müller-Siegmund (2012) and Götz (2016). As the chrono-cultural attribution of sites with microlithic, bladelet-based assemblages in the Eastern Rif cannot sufficiently be carried out with lithic analysis alone, especially with such a small assemblage as is present in Hassi Berkane (Linstädter et al. 2012a), radiometric dating of the layers was needed. ^{14}C dating was carried out in the CologneAMS (Centre for Accelerator Mass Spectrometry, University of Cologne), U-series dating by the Institute of Geosciences, Johannes Gutenberg-Universität Mainz (Denis Scholz). ^{14}C ages were calibrated with CalPal using the CalPal-2007 Hulu calibration curve (Weninger & Jöris 2008), the summed probability distribution of radicarbon ages for Hassi Berkane along with the other Eastern Rif sites was done in R, using the package rcarbon (Bevan & Crema 2020) and the Intcal13 curve (Reimer et al. 2013).

The contextualization of Hassi Berkane along with the other Late Iberomaurusian sites in the Eastern Rif was done by linking them to each other as well as to the landscape using three proxies: site location, resource location in the landscape, and resource use in the sites. With such an approach, we aim to understand the cultural dynamics behind site location and site formation, by analyzing why prehistoric groups chose to settle in which locations (population distribution and settlement orientation) and how they moved through the landscape (mobility).

Population distribution is represented in archaeological contexts by site distribution (Renfrew & Bahn 1996). This is not always straightforward, as the archaeological record is always selective of that which it represents, due to preservation, research history or other biases (Hodder & Orton 1976; Straus et al. 2000). A basic assumption behind site distribution analysis is that the locations of archaeological sites follow some logic, initially unknown to us (Hodder & Orton 1976). We aim to understand this logic by looking for patterns in the distribution and interpreting them.

Another underlying assumption discussed by Hodder & Orton (1976) is that site distribution is inherently linked to resource distribution. We term this concept settlement orientation. If a clustered site pattern is recognized in the Kernel Density Estimation, we can hypothesize that this pattern represents local foci on certain resources in the landscape resources. The question of which resources a site is oriented towards can be answered using Site Catchment Analysis. A site's catchment is defined as *"that area from which a site (or more properly, the inhabitants of a site) derived its resources"* (Roper 1979: 120), and can be divided into different zones. The zone from which inhabitants of a site undertake their daily activities, such as foraging and hunting, can be defined as the *foraging radius* or *daily range*, an "*…area searched and exploited by work parties who leave the camp to exploit the environment and return home in a single day"* (Binford 1982: 7). Identifying the size of this range and mapping the resources accessible in this area around a site can tell us – possibly – which resources the site's location was oriented towards.

Two types of resources were utilized for this analysis: lithic raw material and fresh water. Spatial analysis on the basis of faunal data is outside the scope if this paper, which is to be seen as a preliminary land use characterization that can be expanded with the inclusion of such additional data. Lithic resources were mapped according to previous project results (Linstädter & Müller-Siegmund 2012; Götz 2016). These survey activities showed that cherts from different primary sources are transported far into the region along *wadi* channels, and, therefore, using only the surveyed chert locations for the analysis appeared not to sufficiently reflect the situation on the ground. For this reason, we modeled potential fluvial transport routes of these materials downstream from survey points, by calculating a stream network model with ArcGIS 10.3 using the Flow Accumulation function (Esri, Flow Accumulation) on the basis of the Digital Elevation Model ASTER GDEM V2 (JPL 2009). Values were isolated out of the flow accumulation map if they exceeded 100, an arbitrary threshold selected to ensure a particularly high resolution of the model.

Mobility for resource procurement can extend outside of the area in the immediate vicinity of a site, however. Exploitation outside of this range can be conceptualized as *logistical procurement* (Binford 1980), and the corresponding area utilized – the logistical radius – is *"the zone which is exploited by task groups who stay away from the residential camp at least one night before returning"* (Binford 1982: 7). We can visualize such areas where resource procurement was undertaken outside of the daily range using lithic raw materials (Maier et al. 2016), by linking the artifacts found in the sites back to their sources in the landscape. This analysis is based solely on lithic raw materials, and not typology or technology; accordingly, even small assemblages can be used for such an analysis, although resulting possible biases must kept in mind during the interpretation of the results. We utilize Binford's (1982) concept of *embedded procurement* to demarcate areas used not only for lithic resource collection, but also assume that other procurement activities, such as hunting, were undertaken in these ranges. The resulting maps reflect mobility *potential*, and show broadly circular ranges, encompassing areas not only in the direction of the lithic raw material source itself, but in all directions, to serve as a clearer visualization of distances from a site that were potentially utilized by hunter-gatherer groups.

For the analysis of the site or population distribution, we applied Kernel Density Estimation (Baxter et al. 1997), using the automatic bandwidth calculation by ArcGIS 10.3. To model the different ranges around each site, we applied the method of Site Catchment Analysis presented by Becker et al. (2017) using Tobler's hiking function. These cost-distance maps were divided into a *daily range* of 4h walking time, to ensure travel, procurement and return in one day (Kelly 1995), and the *procurement range* (more neutrally renamed from *logistical range*), defined by the source locations of lithic raw material identified in the sites. The 4h daily ranges were color coded according to the resources available in the range, and the procurement ranges of each lithic raw material was colored and shaded according to the frequency with which the material was found in the site.

Examining the resources available in the daily range allows us to identify potential driving factors behind site location, while analyzing the procurement ranges helps us to discuss hunter-gatherer mobility potential. These analyses, paired with the result of the Kernel Density Estimation, allow us to obtain insight into the Late Iberomaurusian land use strategies of the Moroccan Eastern Rif. All analyses were performed in ArcGIS 10.3.

Hassi Berkane

The rock shelter site of Hassi Berkane (2.87 W, 34.84 N) is named for the small village in Northeastern Morocco, located between the Western foothills of the Beni Snassen mountains and the Eastern outskirts of the Rif mountain range (Er-Rif) (Fig. 1). The site itself is situated to the East of the small town, on a hillside above an abandoned Spanish fort built at the beginning of the 20th century (Fig. 2). Some 50 m to the south of the fort are the rock shelter and freshwater spring which form the center of the site. An up to 2 m thick, ashy, snail-shell rich archaeological layer (*escargotière*) is visible in ditches around the fort's outer walls as well as superficially beneath the rock shelter, allowing a gross estimate of the prehistoric settlement activity in a 2 000 m^2 area around the freshwater spring. In addition to settlement traces found in this area, the team also found sporadic traces of human occupation (lithic material) on the large hillside to the North of Hassi Berkane proper (this new hillside named Hassi Berkane North), attesting to rare anthropogenic use of a currently undetermined nature.

Stratigraphy

Six onsite profiles were documented: two in the ditch along the outer wall of the fort (Western and Eastern "Outer Wall" profiles, OW-W and OW-E), two in the drainage ditch leading away from the fort (Northern and Southern "Drainage Ditch" profiles, DD-N and DD-S), and the two drill cores (HBE1 and HBE2), one taken from underneath the rock shelter (HBE1) and the other in the center of the site (HBE2) (Figs. 2 & 3). Each profile and drill core was photographed, while one profile (OW-W) and both drill cores were additionally described in more detail. The locations of all finds, samples and structures in the cores were measured with DGPS.

All profiles show the same general stratigraphical sequence. Underneath a brown surface layer a (which is missing in some profiles) lies the highly heterogeneous *escargotière* b, divided into multiple sub-layers based on color, composition or delimitations by layers of large stones. In all profiles, a lighter brown layer f was documented underneath the midden.

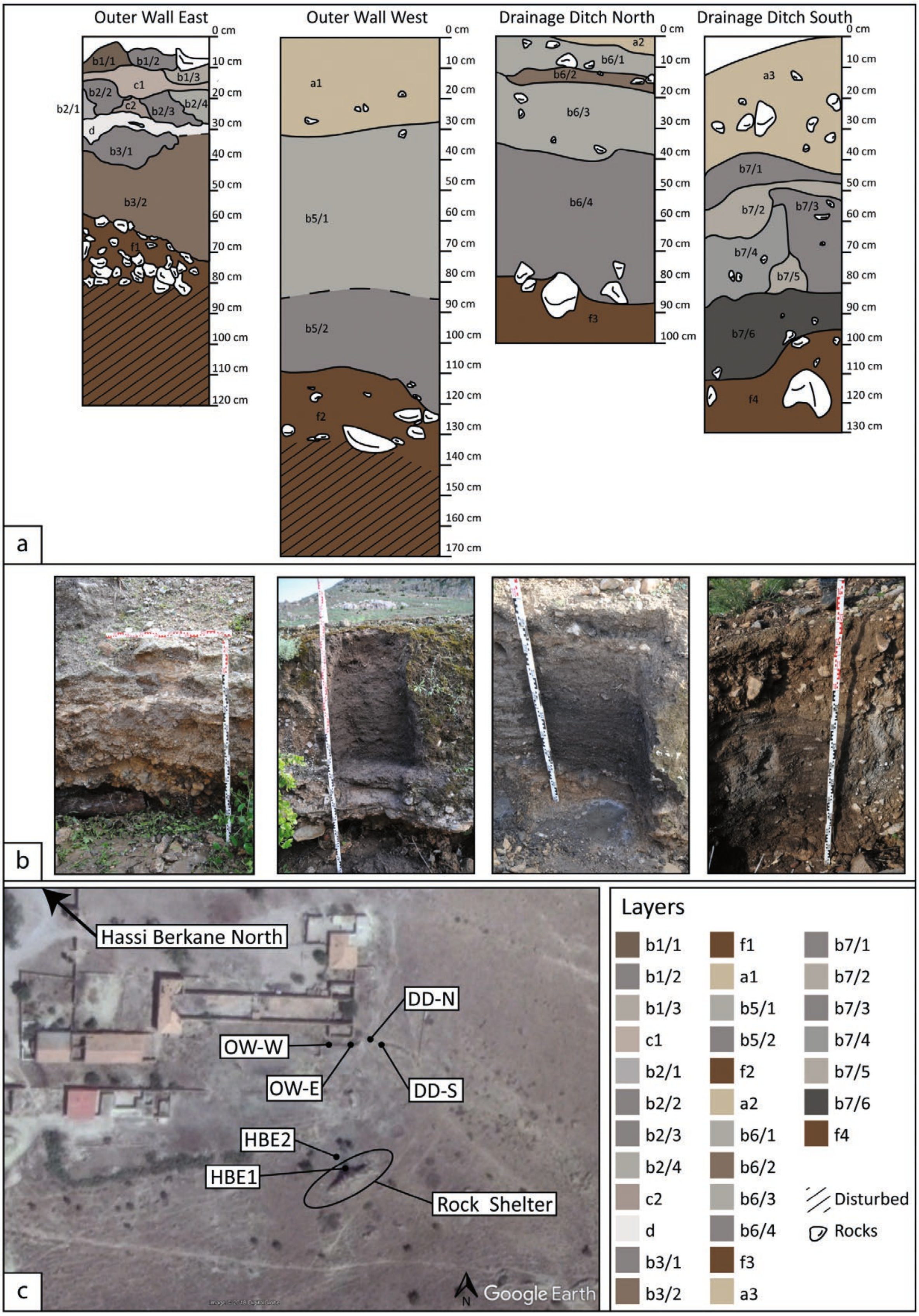

Fig. 2. Situation in Hassi Berkane. a: digitized profiles; b: profile photos; c: situation of the site with location of the profiles (OW-E: profile Outer Wall East; OW-W: profile Outer Wall West; DD-N: profile Drainage Ditch North; DD-S: profile Drainage Ditch South; HBE1: drill core HBE1; HBE2: drill core HBE2).

Abb. 2. *Situation in Hassi Berkane. a: digitalisierte Profile; b: Profilfotos; c: Situation der Fundstelle mit Lokalisierung der Profile (OW-E: Profil Outer Wall East; OW-W: Profil Outer Wall West; DD-N: Profil Drainage Ditch North; DD-S: Profil Drainage Ditch South; HBE1: Bohrkern HBE1; HBE2: Bohrkern HBE2).*

Archaeological finds stem from the midden layers as well as from the underlying sediments. All profiles show signs of running water, mainly in the form of sinter, most likely linkable to the freshwater spring at the site. This is most prominent in the profile OW-W, where the sediments are cemented by precipitated $CaCO_3$.

The surface layer a is likely post-Neolithic or even modern, yielding no artifacts. Layer complex b represents the core of the site, made up of fine, gray, ashy sediment, many stones and especially terrestrial gastropod shells. The main bulk of artifacts with recorded stratigraphical information was found in this layer. The large amount of snail shells is frequently interpreted as remnants of prehistoric meals, marking an intensive, possibly residential settlement of the site (Taylor et al. 2011; Barton & Bouzouggar 2013; Hutterer et al. 2014). Multiple hearths were identified in both drill cores, marked by clusterings of charcoal and burnt stones.

Layers c and d are local phenomena only recorded in the profile OW-W, possibly linked to increased hydrological activity. c is a compact reddish discoloration in the *escargotière*, and d is a thin sinter layer underlying c. From here, samples were taken for U/Th dating. Underneath these two layers, an *escargotière* is visible again. This portion of the midden is particularly cemented, and this cemented layer continues to the East and is visible in the neighboring profile OW-E. This cementation includes the lower portions of the *escargotière* as well as the upper portions of the underlying layer f, the bottom of which is visible in all profiles, marking the lower limit of the sequence. Layer f is not completely sterile, as few artifacts were found in drill core HBE2. In the open profiles OW-E and OW-W, the loose portion of the layer is eroded and only larger stones cemented with the upper portion of the sequence remain.

More archaeological material was found in HBE2 than in HBE1 (Fig. 3 & Appendix, Tab. 1). In both cores, there is a clear focus of the distribution on the *escargotière* layers. In HBE1, we can see a concentration of faunal remains on the presumed hearth structure b8/3, with other material found more evenly, but in lower amounts, throughout the midden sequence. In the other drill core, many artifacts were found in the hearth structure b9/2, but the second probable hearth b9/4 yielded no artifacts; The bulk of the remains and lithics were recovered from the middens themselves, mostly from the lower part of b9/1 and around the small layer of stones in b9/3. Lithics were also recovered from the layers f5 and f6. In f5, two pieces were found in the transition zone from the *escargotière* to the underlying sediment, while four pieces can sufficiently be attributed to the pre-Late Iberomaurusian layer in HBE2. These are the only remains attesting to an earlier settlement of the site; unfortunately, the pieces are not diagnostic. It is possible that these represent an Early Iberomaurusian occupation, but without radiometric ages, this remains unclear.

As the lithic tradition of the Iberomaurusian continues into the Holocene Epipalaeolithic, it is difficult to date a post-Middle Palaeolithic site in this region on the basis of lithic typology and technology alone, especially when the assemblage collected is as small as it is in Hassi Berkane (Linstädter et al. 2012a). For this reason, the chrono-cultural attribution of the assemblages is based solely on ^{14}C-dated samples from the drill core HBE2 and the U/Th dating of the aforementioned flowstone from OW-W (Fig. 4). The age estimates document the use of the site during the Late Iberomaurusian, Epipalaeolithic as well as the Neolithic. The thin sinter layer in OW-W, situated between two layers of *escargotière*, yielded a date of 5.4 ± 0.43 ka, indicating that portions of the shell midden in the front of the site, toward the fort, likely formed in the Late Neolithic. The dates from the drill core in the center of the site (HBE2) attest to a two-phase occupation: one at the beginning of the Late Iberomaurusian, shortly after 15 ka calBP, and one at the beginning of the Epipalaeolithic (Linstädter et al. 2012a).

To examine the contemporaneity of the Hassi Berkane settlement with that of other sites in the region, we calculated summed probability distributions of each site's Iberomaurusian radiocarbon dates (Appendix, Tab. 2 & Fig. 5). The Late Iberomaurusian dates from Hassi Berkane clearly overlap with those from Ifri el Baroud, Ifri n'Ammar and Hassi Ouenzga plein air. The early Epipalaeolithic ages from the site, which calibrate to the very beginnings of the Holocene, are slightly younger than the youngest ages from Hassi Ouenzga plein air and contemporaneous with one isolated early Holocene date from Ifri n'Ammar (Erl-4394). This shows that they can be considered broadly contemporaneous in the sense of an archaeological techno-complex.

Archaeological material

A total of 314 artifacts were collected from the surface or extracted from the profiles. The main portion of artifacts are lithics, making up 224 of the total pieces accounted for; they derive from the surface, the drill cores as well as from the profile OW-W. In addition to these, the next largest find group is faunal remains, comprising of 68 bone fragments and 16 ostrich eggshell pieces. Six pieces of ceramics were found on the surface as well, likely originating from modern use of the site.

The techno-typological analysis of the lithics is based on Tixier 1963. The assemblage is comprised of 24 pieces from HBE1, 91 from HBE2, nine from the profile OW-W, and 100 from the surface (85 from the area between the rock shelter and the fort, and 15 from the area above the rock shelter).

36 artifacts stem from the younger part of the HBE2 sequence, from layer b9/1, and date to the earliest Epipalaeolithic (Appendix, Tab. 1). This assemblage is comprised of 11 bladelets, of which one is

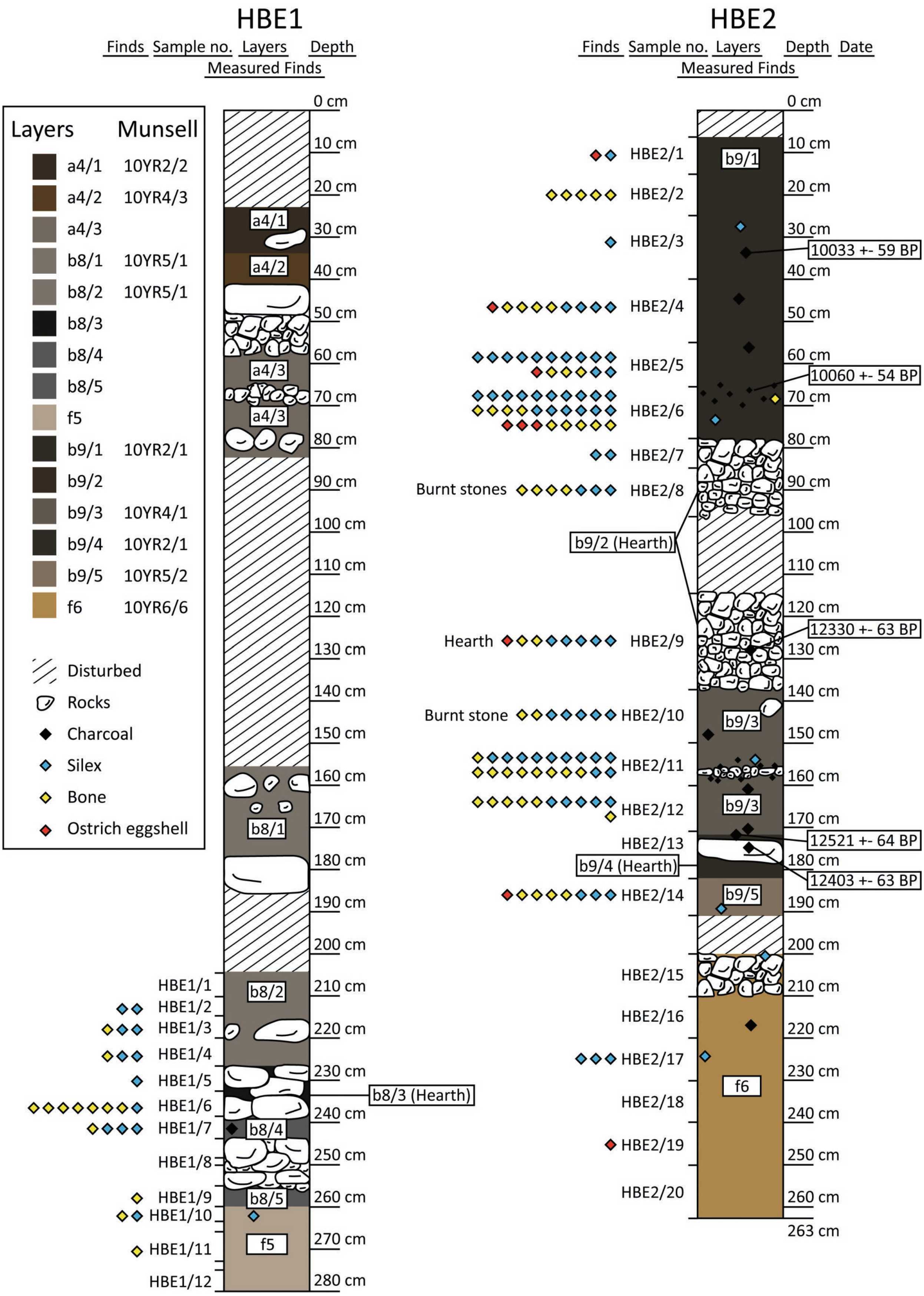

Fig. 3. Drill cores taken in Hassi Berkane.

Abb. 3. *Bohrkerne aus Hassi Berkane.*

Layer	Lab code 14C	14C Age	±	14C Cal BP	±	Material
HAB-b9/1	COL3534.1.1	10 033	59	11 540	150	Charcoal
HAB-b9/1	COL3535.1.1	10 060	54	11 580	150	Charcoal
HAB-b9/3	COL3536.1.1	12 330	63	14 370	180	Charcoal
HAB-b9/3	COL3537.1.1	12 521	64	14 750	210	Charcoal
HAB-b9/4	COL3538.1.1	12 403	63	14 490	200	Charcoal
Layer	**Lab code U/Th**	**Age uncorrected**	**±**	**Age corrected**	**±**	**Material**
HAB-d	HAB-10-KK/6	6 290	170	5 400	430	Flowstone

Fig. 4. Dating results from Hassi Berkane. AMS-14C dating was carried out by the CologneAMS (Centre for Accelerator Mass Spectrometry, University of Cologne), U-series dating by the Institute of Geosciences, Johannes Gutenberg-Universität Mainz (Denis Scholz). 14C ages were calibrated with CalPal and the CalPal-2007 Hulu calibration curve (Weninger & Jöris 2008).

Abb. 4. *Datierungsergebnisse aus Hassi Berkane. AMS-14C-Datierung erfolgte im CologneAMS (Centre for Accelerator Mass Spectrometry, Universität zu Köln), U/Th-Datierung im Institut für Geowissenschaften, Johannes Gutenberg-Universität Mainz (Denis Scholz). 14C-Alter wurden kalibiert mit CalPal und der Calpal-2007 Hulu Kalibrationskurve (Weninger & Jöris 2008).*

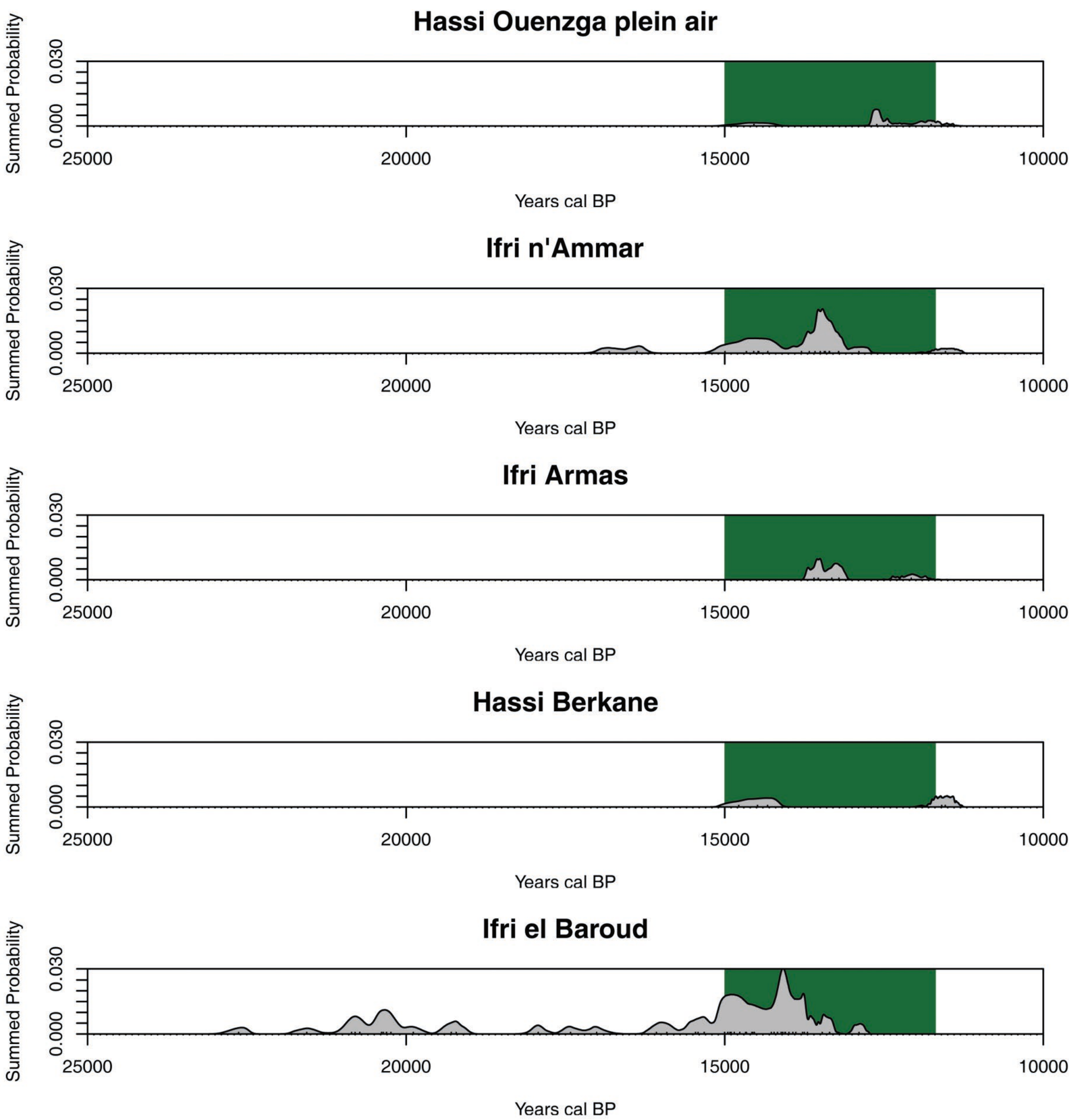

Fig. 5. Summed proability distributions of Iberomaurusian 14C-ages from the Eastern Rif. Calibrated with *rcarbon* (Bevan & Crema 2020) and the Intcal13 calibration curve (Reimer et al. 2013). Marked in green is the age of the Late Iberomaurusian from Potì et al. (2019b).

Abb. 5. *Kumulierte Wahrscheinlichkeitsverteilung der kalibrierten 14C-Alter des Ibéromaurusiens im östlichen Rif. Kalibriert mit rcarbon (Bevan & Crema, 2020) und der Intcal13 Kalibrationskurve (Reimer et al. 2013). Grün hervorgehoben ist das Alter des Späten Ibéromaurusiens nach Potì et al. (2019b).*

retouched into a segment (Tixier type 82; Fig. 6: 8), 12 unretouched flakes, and 13 undiagnostic chips or chunks. From the older, Iberomaurusian part of the sequence, 10 bladelets, two blades, six flakes, and 18 chunks were recovered. The bladelets were retouched into one La Mouillah point (Tixier type 62; Fig. 6: 2), one pointed backed bladelet (Tixier type 51), one denticulated bladelet (Tixier type 77; Fig. 6: 5), and one curved backed bladelet (Tixier type 56; Fig. 6: 3). One microburin was also found (Tixier type 102; Fig. 6: 7). Recovered without stratigraphic position were one bladelet, two flakes, and 10 chips or chunks. All lithics from these layers in HBE2 were made from Moulouya cherts, except three, for which the raw material attribution was not clear.

Other lithics from the *escargotière* without clearly associated dates stem from HBE1 and the profile OW-W. Three bladelets, one blade, and seven chunks were found from the b8 sequence in HBE1: one Ouchtata bladelet (Tixier type 71; Fig. 6: 11) and one chunk from the transition zone between b8/5 and f5, along with four blades, one flake and six chips or chunks potentially from the b8 sequence or the a4 sequence. From the western Outer Wall profile OW-W, nine lithics were recorded: two blades, two bladelets, one flake and four chunks. The flake was retouched into a simple scraper (Tixier type 1; Fig. 6: 13) and one bladelet into a denticulated bladelet (Tixier type 77; Fig. 6: 4).

From the pre-Iberomaurusian layer f, only a few lithics were found, namely from HBE2 (layer f6). These are two undiagnostic flakes and four chips/chunks.

The material found on the surface of the site likely stems from the *escargotière*, as small holes had been dug in multiple places around the site, but lack associated dates. From these areas, more blades were found than in the drill cores; the material from HBE1 and HBE2 is in general much smaller than the surface finds. One of the 23 blades was retouched into a blade with Ouchtata retouch (Tixier type 71; Fig. 6: 10), while one of the six bladelets was retouched into a backed bladelet (Tixier type 67; Fig. 6: 1); here, another microburin was found (Fig. 6: 6). In this surface collection, 18 flakes were also found, one as a simple scraper on flake (Tixier type 1; Fig. 6: 14). From the upper part of the site, on the hillside above the rock shelter, four bladelets were found (one of which is a dihedral burin (Tixier type 27; Fig. 6: 9), along with four unretouched flakes and one chunk. Here and in the area underneath the rock shelter, three cores were found (Fig. 6: 15-17). These are small unidirectional bladelet cores and attest to on-site lithic production following the scheme described by (Tixier 1963). No cores were found in the drill core sequences.

Many artifacts show traces of thermal influence. 32 of all 124 artifacts from the drill cores and the profile OW-W were heated and were found throughout the complete sequence. These traces are possibly linked to the omnipresence of fire documented in the form of hearths and ash in the whole *escargotière*.

A total of 144 pieces had remains of cortex, and 75 of these are either blades, bladelets, flakes or cores. 44 of these stem from the surface collections and four from the profile OW-W. The remaining 27 pieces come from the drill-cores (two from HBE1, 25 from HBE2); of these, 11 date to the Epipalaeolithic occupation layer b9/1, and seven from the Late Iberomaurusian layers b9/2 (n = 2), b9/3 (n = 2) and b9/5 (n = 3). Seven of all 75 knapped pieces with cortex were retouched into tools (two Ouchtata bladelets (Tixier type 71), two scrapers (type 1), one La Mouillah point (type 62), one denticulated bladelet (type 77), one backed bladelet (type 67), one final piece is a microburin (type 102)) .

The materials for the lithic production were collected almost exclusively from the Moulouya river, a secondary outcrop ca. 10 km away from the site that yields two different types of chert, both washed down the river from a currently unknown primary resource (Nami 2007; Linstädter & Müller-Siegmund 2012). The first variant is a coarse-grained, white-grayish material with a light brown to almost orange cortex ("Moulouya white"). The more common "Moulouya brown" is not only brown, but reddish, yellowish, even gray to black (Linstädter et al. 2012b; Götz 2016). All pieces have a rounded cortex attesting to their fluvial transport and are often battered. This material was also used in great quantities in neighboring sites such as Ifri n'Ammar (Moser 2003) and Ifri el Baroud (Potì et al. 2019b).

Only one artifact likely stems from a different source, from a primary outcrop near the town of Ain Zora, 64 km away from the site (Nami 2007; Götz 2016). The black-brown material with a chalky cortex is not only available at the outcrop itself, but also transported along *wadis* to the north into the *Pleine du Guerrouaou* as well as to the south, where it merges with the Moulouya river channel. It is therefore possible that this piece was also collected with the others from the Moulouya and that the raw material procurement was exclusively local.

Few artifacts were made from limestone; the source of this material is currently unknown.

In addition to the lithic artifacts, faunal remains were recorded throughout the drill cores (Fig. 3). Malacofaunal remains were present in the sediments, but not collected. Unfortunately, all remains are highly fragmented and undiagnostic, with the exception of ostrich eggshells. Nine eggshell fragments were found in stratigraphic position in HBE2, along with seven further pieces from the same drill core without recorded stratigraphic position (from layers b9/1 to b9/5). Found along with these, also lacking stratigraphic information, was a human tooth, which could originate from the Epipalaeolithic layer b9/1 or the Late Iberomaurusian layers b9/2 to b9/5. The tooth was destroyed during ^{14}C dating, but a CT-scan was generated prior to dating (Fig. 7). Dating was, unfortunately, not possible due to the lack of sufficient organic

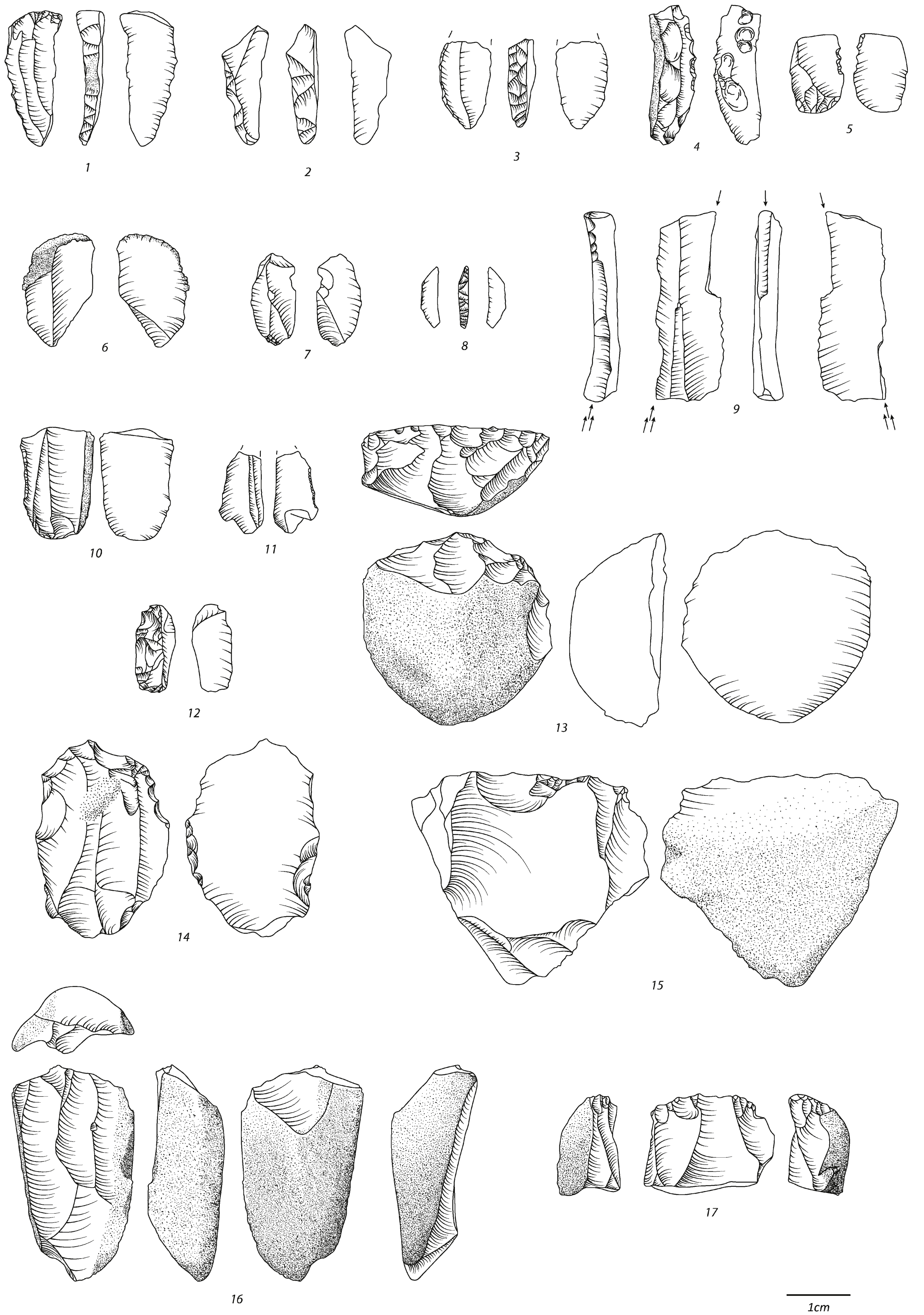

Fig. 6. Lithic artifacts from Hassi Berkane. 1: Backed bladelet; 2: La Mouillah point; 3: Curved backed bladelet; 4-5: Denticulated bladelet; 6-7: Microburin; 8: Segment; 9: Dihedral burin; 10-11: Ouchtata bladelet; 12: Pointed backed bladelet; 13-14: Simple scraper on flake; 15-17: Bladelet core.

Abb. 6. *Steinartefakte aus Hassi Berkane. 1: Rückengestumpfte stumpfwinklige Lamelle; 2: La Mouillah Spitze; 3: Rückengestumpfte gebogene Lamelle; 4-5: Gezähnte Lamelle; 6-7: Kerbrest; 8: Segment; 9: Gemischter Mehrfachstichel; 10-11: Ouchtata Lamelle; 12: Spitze Lamelle mit geradliniger Rückenstumpfung und retuschierter Basis; 13-14: Einfacher Kratzer an Abschlag; 15-17: Lamellenkern.*

material. This find is notable, as human remains are a common appearance in Late Iberomaurusian assemblages of the Eastern Rif (Mikdad & Eiwanger 2000; Ben-Ncer 2004; Lorenz 2010; Humphrey et al. 2012).

Due to the minimally invasive nature of the field work at Hassi Berkane, the assemblage size remains small. However, the data available allows us to tentatively deduce that the inhabitants of Hassi Berkane utilized a bladelet-based industry typical of the Late Upper Palaeolithic and Epipalaeolithic societies in the Eastern Rif (Tixier 1963). They likely collected their raw materials from within a day's walk from camp and probably processed them directly at the site, as multiple stages of tool production were identified (cores, blanks, retouched tools) and many cortical pieces were found. Stark similarities between Late Iberomaurusian and Epipalaeoltihic lithic assemblages in the Eastern Rif (Linstädter et al. 2012a) along with the lack of material clearly associated with the Late Neolithic date in Hassi Berkane make it impossible to attribute the material from the surface collections to one of the three identified occupation phases of this site. The chrono-cultural attribution can only be undertaken on the basis of radiometric age analyses (Figs. 4 & 5).

Hassi Berkane represents an important site in the Late Iberomaurusian and Epipalaeolithic settlement systems of the Eastern Rif. Interestingly, the Upper Palaeolithic dates here show that settlement began just after the transition from the late phase of Heinrich Event 1 (Fletcher et al. 2010), corresponding to the Early Iberomaurusian, to Greenland Interstadial 1, where prehistoric groups began the mass exploitation of terrestrial gastropods (transition ca. 16-15 ka calBP) (Linstädter et al. 2012a; Potì et al. 2019b). Therefore, Hassi Berkane has the potential to tell us more about the very beginnings of this enigmatic phase, and may help us identify driving factors behind this subsistence shift.

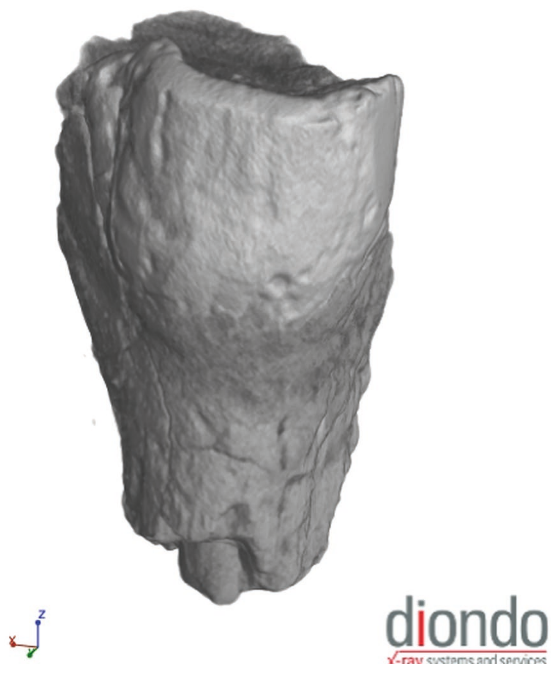

Fig. 7. CT-scan of a human tooth from the drill core HBE2 from Hassi Berkane.

Abb. 7. *CT-Scan eines menschlichen Zahns aus dem Bohrkern HBE2 von Hassi Berkane.*

Analysis of land use and mobility of the Late Iberomaurusian in the Eastern Rif

In order to gain insight into land use and mobility patterns, we must contextualize this new site in the landscape, along with the other previously discovered sites Ifri el Baroud, Ifri n'Ammar, Hassi Ouenzga plein air and Ifri Armas. This is done by analyzing site distribution, settlement orientation in regard to resource locations, and mobility using lithic raw material data from the assemblages, as described above. The first analysis, the Kernel Density Estimation, has a fairly straightforward result. In figure 8, only low density values were recorded. The few sites are distributed fairly evenly in the interior of the study area of the Eastern Rif, and no clear clusters can be identified.

For the site catchment analyses, we first needed to localize potential resources in the study area. We focused on lithic and freshwater resources for the current analysis, as the impact of faunal resources on Iberomaurusian land use patterns is being analyzed in an ongoing PhD dissertation. We incorporated the two previously described lithic raw materials form the Moulouya and from Ain Zora, and a third lithic variant, called "Oumassine chert". This reddish-yellow material can also be collected in *wadi* channels in the Melilla region in the North of the study area. Three additional materials were mapped: "Zafrin radiolarite" and "Ammorene" and "In-Narramine quartzites" (Jebb 2009; Gibaja et al. 2012). As these materials were not recorded in Late Iberomaurusian assemblages, they are not discussed further.

To model the potential fluvial distribution of the cherts, we calculated the stream network model (Fig. 9). Ain Zora chert potentially travels to the North and to the South of the study area. The northern route takes the material through the *Pleine du Guerrouaou*, where Ifri el Baroud and Hassi Ouenzga plein air are located, and along the river Oued Kert. The southern transport route flows into the Moulouya, where it would be mixed with the other colorful Moulouya chert variants.

The flow accumulation model also helped identify potential fresh water sources (Fig. 10). We marked the rivers Oued Kert and Moulouya as potential water sources. Although it is unclear to which degree these were perennial rivers during the Late Iberomaurusian, there are some indicators that water was available in these general areas in prehistoric times (Jebb 2009;

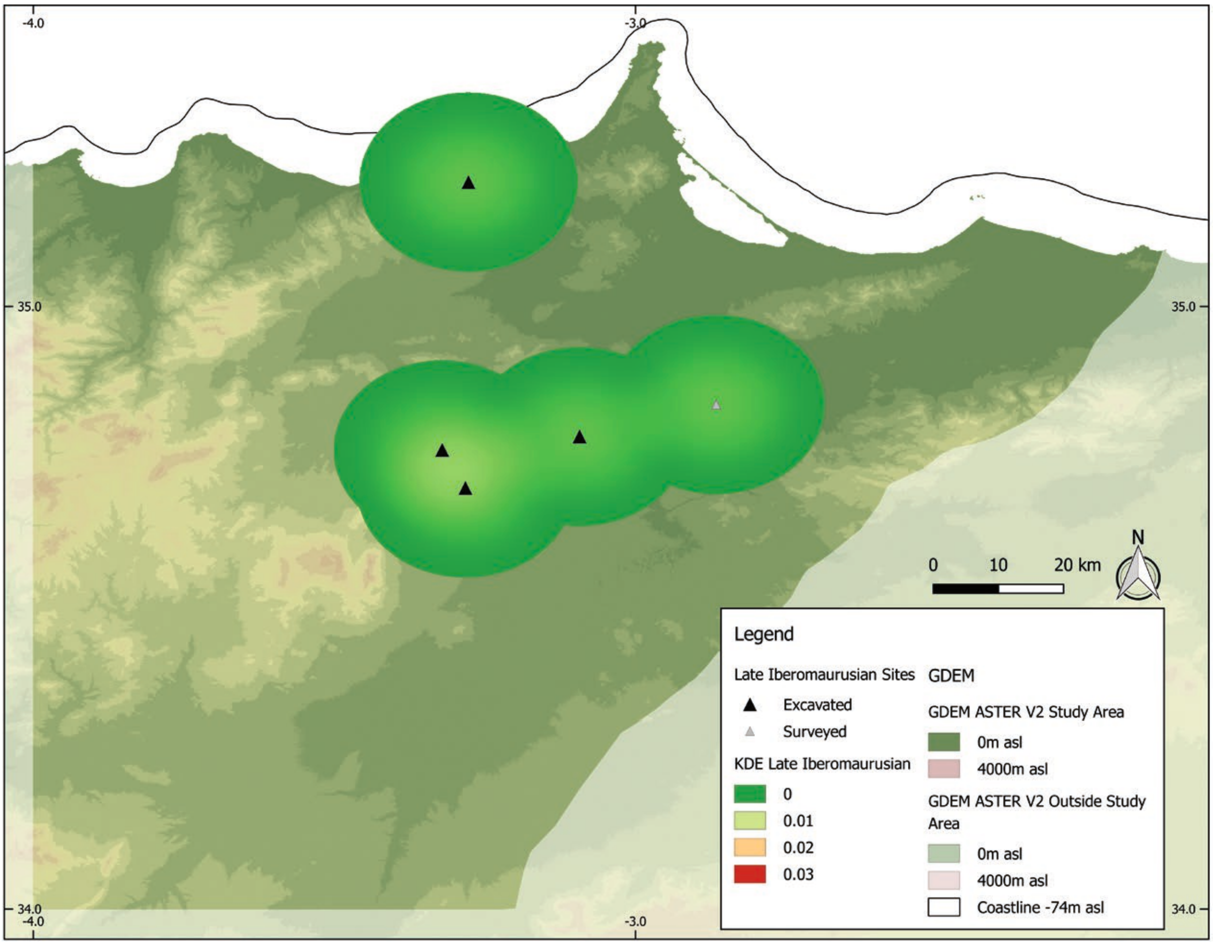

Fig. 8. Kernel Density Estimation of Late Iberomaurusian sites in the Eastern Rif. Digital Elevation Model from JPL 2009. Coastline at 74 m below present sea level from Zickel et al. (2016).

Abb. 8. *Kerndichteschätzung von Fundstellen des späten Ibéromaurusien im östlichen Rif. Digitales Geländemodell von JPL 2009. -74 m Isobathe von Zickel et al. (2016).*

Rixhon et al. 2017). In addition to these, we marked freshwater springs, such as the one at Hassi Berkane; another freshwater spring is located at the site of Hassi Ouenzga, and two others are in the North of the study area, at the sites Ammorene and In-Narramine (Jebb 2009). Finally, in the stream network model, we observed a basin structure in the center of the study area, in the *Pleine du Guerrouaou*; it is unclear if this structure represents a stable lake that was available as a water source throughout the Late Glacial, but the general topography of the area would encourage the collection of fresh-water reservoirs, and it is possible that a resulting hydrological structure had the potential to influence prehistoric settlement patterns.

We began the site catchment analyses by overlaying these resource locations with the 4h catchments we had calculated for each site (Fig. 11). We then color-coded each of these ranges according to the resources available in them, marking ranges with access to both freshwater and lithic resources in green, and resources with only access to water in blue. It is notable that all sites have access to water in their daily ranges. Lithic resources are, in three of five cases, located near the edges of the daily ranges (but still inside), and in the other two only slightly beyond. Interestingly, the sites are never situated immediately at the resources, but always some distance away. This is in contrast to later phases, as the Epipalaeolithic and Neolithic inhabitants of the region opted to sit directly at their resources (Linstädter et al. 2012b; Otto 2018). These increased distances to lithic resources in the daily range is notable, as well as the strong orientation towards fresh water. This result shows that fresh water was likely a driving force behind settlement location choice, and that the Late Iberomaurusian groups were likely fairly mobile in their daily foraging activities.

Daily foraging is only one type of mobility, however. The previous result tells us that the groups chose settlement areas that were rather far away from the closest resources, but not necessarily how far they were moving overall to collect their resources. To analyze this, we used data from the individual assemblages. In each site, we counted the frequency with which each lithic raw material was used during the Late Iberomaurusian and took this as a proxy for mobility frequency (Fig. 12). Data from Ifri Armas could not be used, as the complete sequence is mixed and it was not possible to isolate the Late Iberomaurusian assemblage.

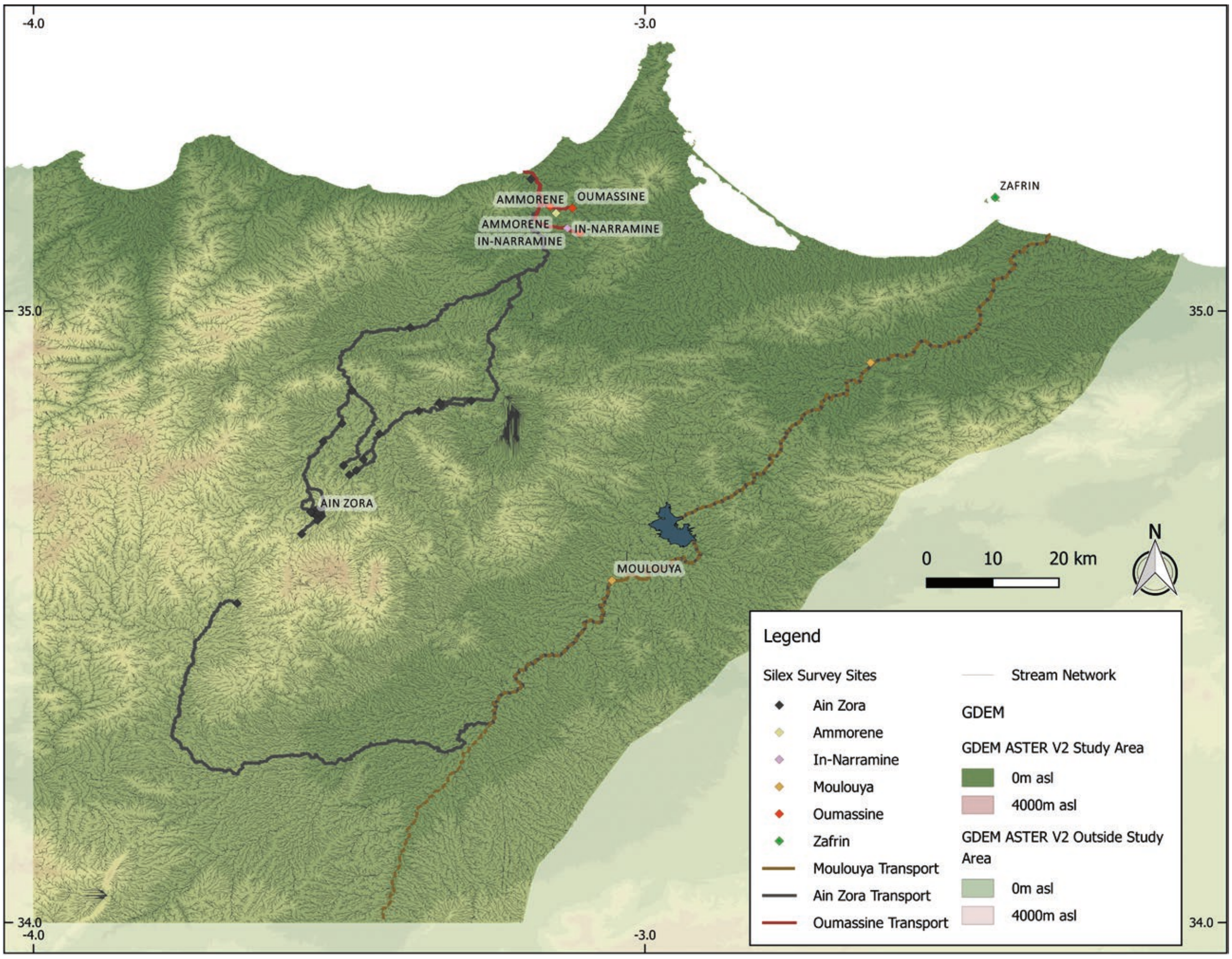

Fig. 9. Location of surveyed and modeled lithic outcrops in the Eastern Rif. Digital Elevation Model from JPL 2009.

Abb. 9. *Prospektierte und modellierte lithische Rohmaterialquellen im östlichen Rif. Digitales Geländemodell von JPL 2009.*

For Ifri n'Ammar, we could only account for presence or absence of Moulouya and Ain Zora cherts, as this data was not reported quantitatively in Moser (2003). From Hassi Berkane, we only selected the stratified material dated to the Late Iberomaurusian. Only this site shows a clear preference for one type of raw material; Ifri el Baroud (Potì 2017) and Hassi Ouenzga plein air (J. Holzkämper, unpubl. data) used both Moulouya and Ain Zora cherts evenly, with some traces of Oumassine material.

By inputting this data into the site catchment analysis, we obtained a map of procurement ranges for each Iberomaurusian site (Fig. 13). The size of each range corresponds to the closest collection point of each raw material, and the shade and transparency of each range corresponds to the frequency with which the material was used. The darker, more opaque areas were utilized more frequently than the lighter, translucent ones. The maximum procurement ranges of Ifri el Baroud (IB) and Hassi Ouenzga plein air (HO_PA) are particularly large, but these represent only trace quantities of Oumassine chert found in the assemblages. Most of the raw material procurement from these sites is restricted to the darker-shaded areas, in the broadly triangular region between Oued Kert, Ain Zora and the Moulouya. The results from Ifri el Baroud show that Ain Zora chert, available closest to the sites, was used most often, as well as a notable amount of Moulouya cherts, located farther away. The inhabitants of Hassi Ouenzga plein air used both types with almost the same frequency, showing that travels to the Moulouya were undertaken just as often as to the more local source. Hassi Berkane (HAB) has the smallest procurement range, which is only slightly smaller than its daily range; as the assemblage is relatively small, this can only be treated as a preliminary result.

The combined result of all analyses for the Late Iberomaurusian land use shows that the hunter-gatherer groups only very rarely moved toward the coast, likely linked to the use of Ifri Armas, and that most mobility was restricted to the hinterland, in a region large enough to be traversed in roughly a two-day's walk. In contrast, they were fairly mobile in their daily foraging activities, as sites are never situated directly at the resources they used. The general land use pattern can be characterized as a homogeneous, somewhat mobile exploitation of a small, suitable habitat.

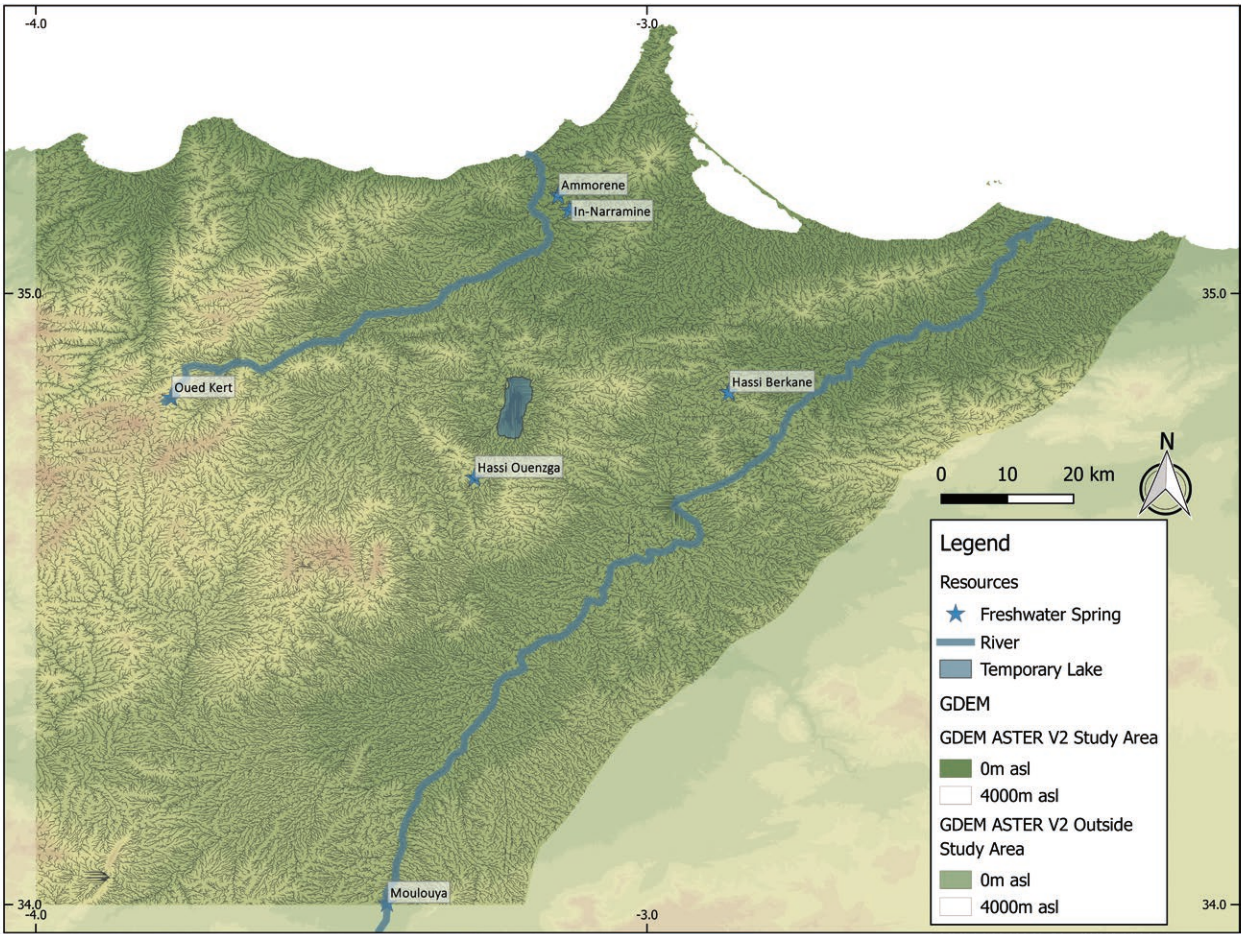

Fig. 10. Location of surveyed and modeled fresh water sources in the Eastern Rif. Digital Elevation Model from JPL 2009.

Abb. 10. *Prospektierte und modellierte Süßwasserquellen im östlichen Rif. Digitales Geländemodell von JPL 2009.*

Discussion

Hassi Berkane is unique in the observation that the assemblage yielded mainly lithics from the Moulouya river, as opposed to materials from both the Moulouya and Ain Zora. Due to the small sample size, it is difficult to interpret this observation further. In general, the resource use pattern at this site is similar to that from neighboring sites, with a focus on more local raw materials and only rare long-distance movements. This aligns nicely to the pattern previously observed by Potì et al. (2019b), who highlight the shift toward the exploitation of local raw materials (Ain Zora) in the Late Iberomaurusian as opposed to the utilization of the more distant Moulouya cherts in the Early Iberomaurusian.

Other authors hypothesize that habitat suitability and sedentary behavior might have increased during the Late Iberomaurusian after Heinrich Event 1 (Humphrey et al. 2014; Morales 2018). Barton et al. (2013) link this to an increase in precipitation and dietary breadth, reflected by (not only) the exploitation of land snails (Taylor et al. 2011). Weniger et al. (2019) show that the Moroccan settlement of the Late Glacial is more stable than the contemporary settlement of the South of the Iberian Peninsula: Heinrich Event 1 seems to have significantly impacted hunter-gatherer groups in Southern Iberia, so that they were not able to bounce back during GI1, when the climate got better. In Morocco, on the other hand, we see an increase in sites and the mass consumption of terrestrial gastropods during GI1. Such observations by various authors agree to a large extent that a change in land use becomes visible in the late Iberomaurusian, which may be associated with environmental change or reflect a particular new form of resource exploitation. An increase in habitat suitability can go hand-in-hand with a decrease in mobility and an increase in resource predictability (Dyson-Hudson & Smith 1978; Stein Mandryk 1993). Therefore, the links between climate, mobility, dietary breadth, and resource predictability need to be examined further, in order to better understand the dynamics behind the Late Iberomaurusian land use patterns. Especially the predictability of utilized faunal resources – not only terrestrial gastropods, but also large and small game – needs to be incorporated into the discussion. We can hypothesize that there is a connection between the land use pattern a group employed and the faunal resources they exploited, such as a link

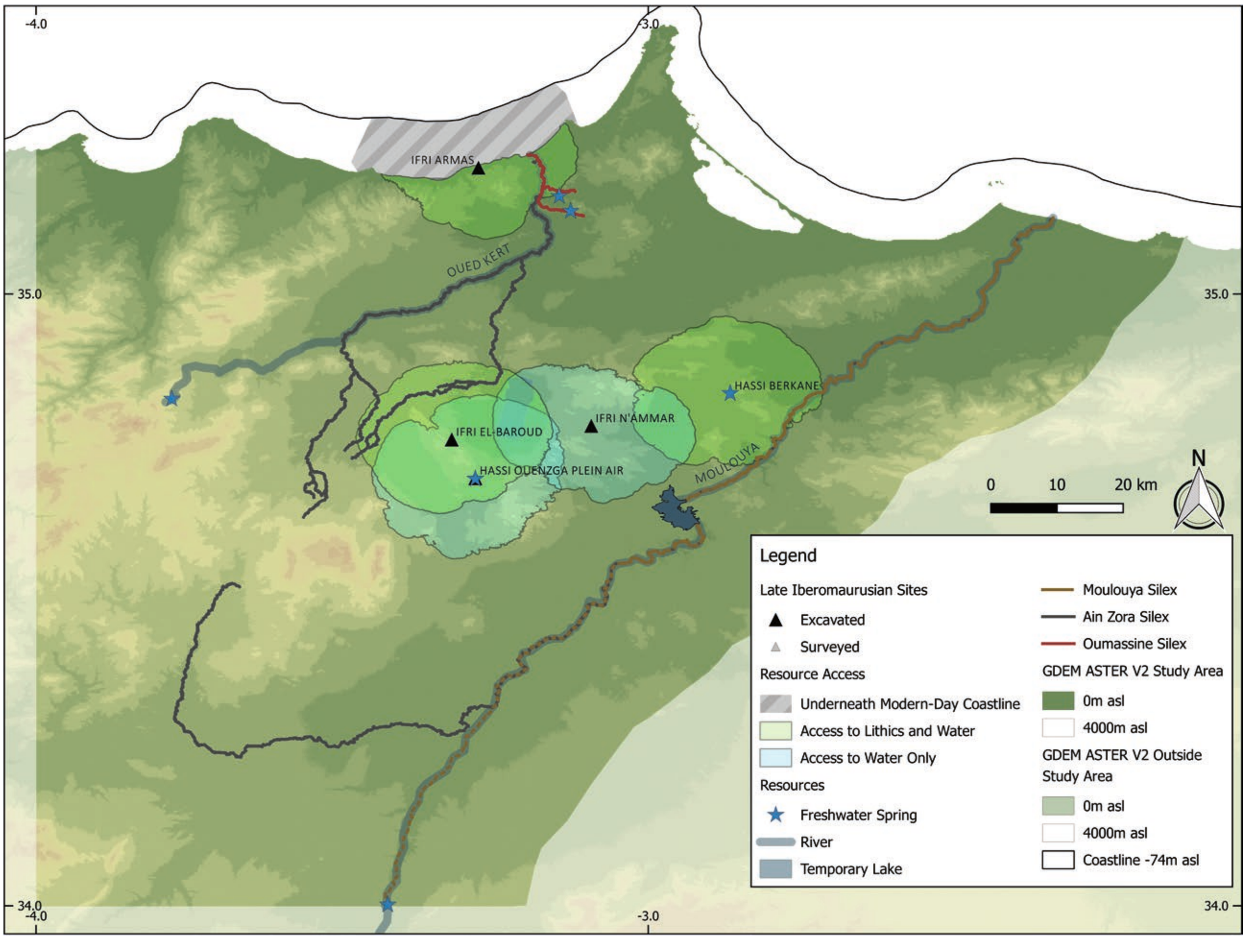

Fig. 11. Daily range of Late Iberomaurusian sites in the Eastern Rif. Digital Elevation Model from JPL 2009. Coastline at 74 m below present sea level from Zickel et al. (2016).

Abb. 11. *Tägliches Schweifgebiet von Fundstellen des späten Ibéromaurusien im östlichen Rif. Digitales Geländemodell von JPL 2009. 74 m Isobathe von Zickel et al. (2016).*

between a fairly immobile society and a staple resource that also is not assumed to be fairly mobile (Linstädter 2014). A particularly challenging question is whether the increased habitat suitability implied by these results derives from climate conditions or from a conscious resource selection which included gastropods, which is not observed for contemporaneous groups in Southern Iberia, who were living in similar climate conditions to those in the Eastern Rif. Examining these dynamics more closely may help us identify driving factors behind the inclusion of snails into the subsistence pattern as well as its impact on land use patterns and long-term settlement stability. The Iberomaurusian in Morocco therefore offers one of the rare opportunities in the Palaeolithic record to understand the interrelationships of cultural and environmental change more deeply.

	Ain Zora	Moulouya	Oumassine	Silex unspec.	Other
Ifri n'Ammar	+	+	-	+	+
Ifri el Baroud	4 428 (*48.4 %*)	3 951 (*43.2 %*)	14 (*0.2 %*)	71 (*0.8 %*)	693 (*7.6 %*)
Hassi Berkane	-	36 (*94.7 %*)	-	2 (*5.3 %*)	-
Hassi Ouenzga plein air C3/C4	553 (*50.8 %*)	531 (*48.8 %*)	1 (*0.1 %*)	-	4 (*0.4 %*)
Hassi Ouenzga plein air C5	94 (*46.3 %*)	107 (*52.7 %*)	1 (*0.5 %*)	1 (*0.5 %*)	-

Fig. 12. Lithic raw materials used in Late Iberomaurusian sites in the Eastern Rif.

Abb. 12. *In Fundstellen des späten Ibéromaurusien im östlichen Rif verwendete lithische Rohmaterialien*

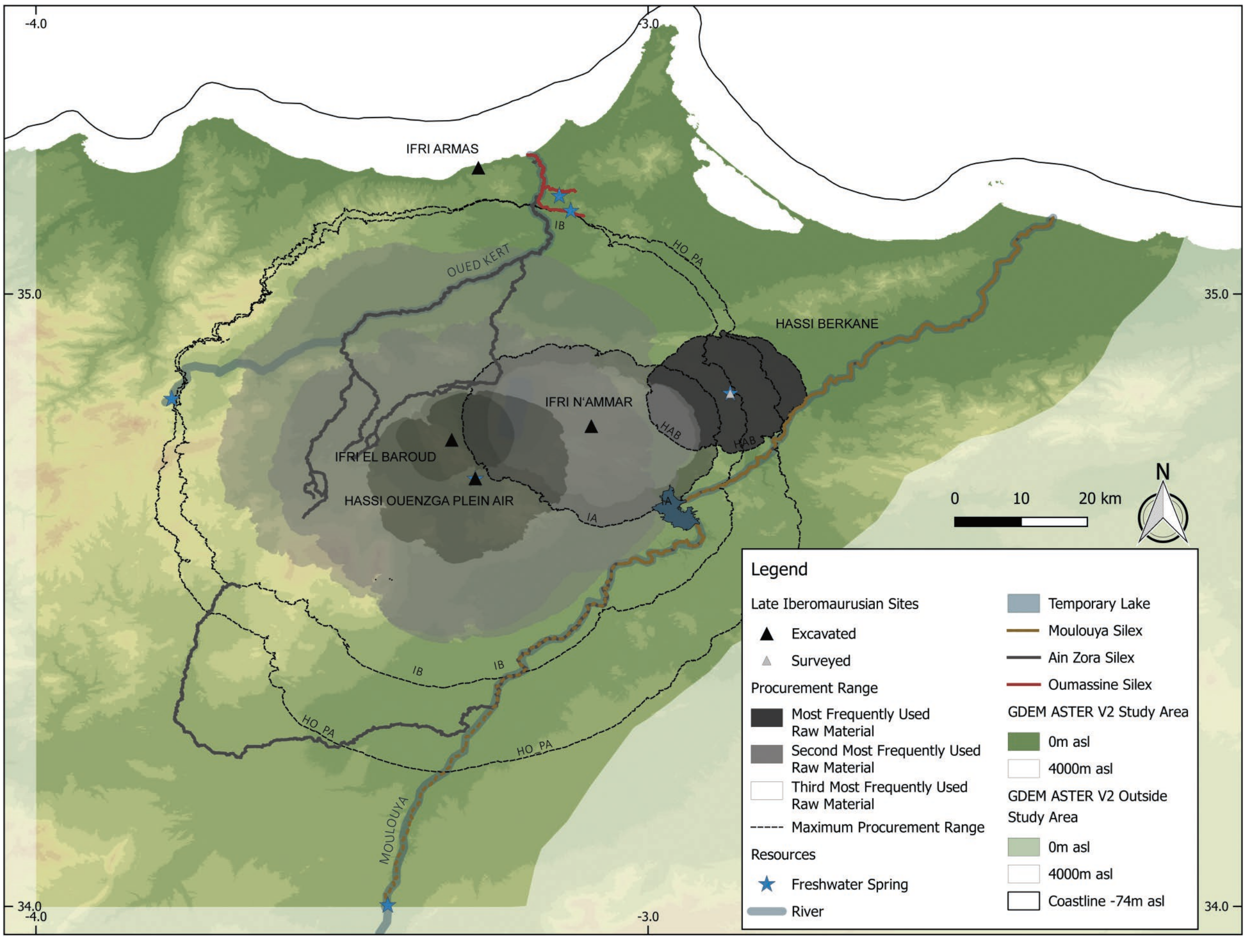

Fig. 13. Procurement ranges of Late Iberomaurusian sites in the Eastern Rif. Site codes: IA = Ifri n'Ammar, IAR = Ifri Armas, IB = Ifri el Baroud, HAB = Hassi Berkane, HO_PA = Hassi Ouenzga plein air. Digital Elevation Model from JPL 2009. Coastline at 74 m below present sea level from Zickel et al. (2016).

Abb. 13. *Rohmaterialbeschaffungsgebiete von Fundstellen des späten Ibéromaurusien im östlichen Rif. Codes der Fundstellen: IA = Ifri n'Ammar, IAR = Ifri Armas, IB = Ifri el Baroud, HAB = Hassi Berkane, HO_PA = Hassi Ouenzga plein air. Digitales Geländemodell von JPL 2009. 74 m Isobathe von Zickel et al. (2016).*

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Area	Techno-complex	Layer	Raw Material	Blank	Type (Tixier 1963)	n	no. Fig 4
HBE1	undated	a4/1 - a4/3 or b8/1 - b8/5	Moulouya brown	bladelet		4	
				flake		1	
				chunk		5	
			undecidable	chunk		1	
	undated	b8/2	Moulouya brown	bladelet		3	
				blade		1	
				chunk		2	
	undated	b8/3	Moulouya brown	chunk		2	
	undated	b8/4	Moulouya brown	chunk		3	
	undated	transition b8/5 to f5	Moulouya brown	bladelet	Lamelle à retouche Ouchtata (71)	1	11
				chunk		1	
HBE2	Epipalaeolithic	b9/1	Moulouya brown	bladelet	Segment ou demi-cercle (82)	1	8
				bladelet		10	
				flake		12	
				chunk		12	
			undecidable	chunk		1	
	Late Ibero-mau-rusian	b9/2	Moulouya brown	bladelet	Lamelle à bord abattu arquée (56)	1	3
				bladelet	Microburin (102)	1	7
				bladelet		1	
				blade		1	
				flake		2	
				chunk		4	
		b9/3	Moulouya brown	bladelet	Lame ou lamelle denticulée (77)	1	5
				bladelet		3	
				blade		1	
				flake		3	
				chunk		10	
			Moulouya white	chunk		2	
			undecidable	chunk		2	
		b9/5	Moulouya brown	bladelet	Pointe de La Mouillah (62)	1	2
				bladelet	Lamelle aiguë à bord abattu rec-tiligne et base retouchée (51)	1	
				blade		1	
				flake		1	
	undated	f6	Moulouya brown	flake		2	
				chunk		4	
	Late Ibero-mauru-sian or Epipalaeo-lithic	b9/1 - b9/5	Moulouya brown	blade		1	
				flake		2	
				chunk		10	
OW-W	undated	b3/2	Moulouya brown	bladelet	Lame ou lamelle denticulée (77)	1	4
				bladelet		1	
				blade		1	
				flake	Grattoir simple sur éclat (1)	1	13
				chunk		3	
	undated		undecidable	blade		1	
				chunk		1	

Appendix, Tab. 1. continued next page.

Appendix, Tab. 1. *Fortsetzung nächste Seite.*

Area	Techno-complex	Layer	Raw Material	Blank	Type (Tixier 1963)	n	no. Fig 4
Surface Rock shelter	undated	surface	Ain Zora	core	Unidirectional bladelet core	1	15
			Moulouya brown	bladelet	Lamelle obtuse à bord abattu (67)	1	1
				bladelet		5	
				blade	Lame à retouche Ouchtata (71)	1	10
				blade	Microburin (102)	1	6
				blade		19	
				flake		14	
				core	Unidirectional bladelet core	1	17
				chunk		33	
			Moulouya white	blade		1	
				flake	Grattoir simple sur éclat (1)	1	14
				flake		2	
				core	Unidirectional bladelet core	1	
				chunk		2	
			Limestone	blade		1	
				flake		1	
Surface Hillside	undated	surface	Moulouya brown	bladelet		3	
				flake		3	
				core	Unidirectional bladelet core	1	16
				chunk		6	
			Moulouya white	bladelet	Burin multiple mixte (27)	1	9
				flake		1	

Appendix, Tab. 1. Lithics from Hassi Berkane.

Appendix, Tab. 1. *Steinartefakte aus Hassi Berkane.*

Site	Context	Lab Nr	^{14}C Age	^{14}C Stdev	Material	Reference
Ifri el Baroud	B2	Beta-463097	12 160	40	Charcoal	Potì et al. 2019a
Ifri el Baroud	B2	Beta-463098	12 040	40	Charcoal	Potì et al. 2019a
Ifri el Baroud	B2	Beta-463099	12 430	40	Charcoal	Potì et al. 2019a
Ifri el Baroud	B2	Beta-463100	12 220	40	Charcoal	Potì et al. 2019a
Ifri el Baroud	B1	Beta-463101	12 440	40	Charcoal	Potì et al. 2019a
Ifri el Baroud	B1	COL3761.1.1	12 477	58	Charcoal	Potì et al. 2019a
Ifri el Baroud	B1	COL3762.1.1	12 547	60	Charcoal	Potì et al. 2019a
Ifri el Baroud	B1	COL3763.1.1	12 514	62	Charcoal	Potì et al. 2019a
Ifri el Baroud	B1	COL3764.1.1	12 577	63	Charcoal	Potì et al. 2019a
Ifri el Baroud	B1	COL3765.1.1	12 444	62	Charcoal	Potì et al. 2019a
Ifri el Baroud	B1	COL3766.1.1	12 582	63	Charcoal	Potì et al. 2019a
Ifri el Baroud	C	COL3767.1.1	13 235	62	Charcoal	Potì et al. 2019a
Ifri el Baroud	C	COL3768.1.1	14 005	67	Charcoal	Potì et al. 2019a
Ifri el Baroud	C	COL3769.1.1	14 732	72	Charcoal	Potì et al. 2019a
Ifri el Baroud	C	COL3770.1.1	15 932	76	Charcoal	Potì et al. 2019a
Ifri el Baroud	C	COL3771.1.1	15 985	81	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3772.1.1	16 837	81	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3773.1.1	16 902	83	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3774.1.1	16 878	81	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3775.1.1	17 249	80	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3776.1.1	17 296	87	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3777.1.1	17 183	123	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3778.1.1	12 907	65	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3779.1.1	18 768	103	Charcoal	Potì et al. 2019a
Ifri el Baroud	D	COL3780.1.1	17 798	91	Charcoal	Potì et al. 2019a
Ifri el Baroud	II, IB95-A	Bln-4744	16 777	83	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	II, IB95-A	Bln-4745	13 359	72	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	II, IB95-D	Bln-4746	12 626	59	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	II, IB95-E	Bln-4747	12 481	57	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	II, IB95-F	Bln-4748	12 574	65	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	II, IB95-H	Bln-4749	12 253	67	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	II, IB95-L	Bln-4750	11 508	60	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	II, IB95-M 47	Bln-4751	14 299	72	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	III, IB95-P	Bln-4752	12 128	70	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	III, IB95-Q	Bln-4753	12 198	65	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	III, IB95-R	Bln-4754	11 895	64	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	III, IB96-A (41)	Bln-4871	11 639	58	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-C	Bln-4873	12 932	78	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-68	Bln-4911	16 485	68	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-4	Bln-4926	11 027	49	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-5	Bln-4927	12 294	49	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-21	Bln-4928	11 926	68	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-38	Bln-4929	12 172	61	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-49	Bln-4930	12 841	80	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-51	Bln-4931	12 083	61	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-83	Bln-4932	12 607	75	Charcoal	Bouzouggar et al. 2008
Ifri el Baroud	IV, IB96-94	Bln-4933	11 946	52	Charcoal	Bouzouggar et al. 2008

Appendix, Tab. 2. continued next page.
Appendix, Tab. 2. *Fortsetzung nächste Seite.*

Site	Context	Lab Nr	^{14}C Age	^{14}C Stdev	Material	Reference
Ifri el Baroud	IV, IB96-96	Bln-4934	12 309	58	Charcoal	Bouzouggar et al. 2008
Hassi Berkane	HAB-B9/3	COL3537.1.1	12 521	64	Charcoal	This paper
Hassi Berkane	HAB-B9/3	COL3538.1.1	12 403	63	Charcoal	This paper
Hassi Berkane	HAB-B9/3	COL3536.1.1	12 330	63	Charcoal	This paper
Hassi Berkane	HAB-B9/1	COL3535.1.1	10 060	54	Charcoal	This paper
Hassi Berkane	HAB-B9/1	COL3534.1.1	10 033	59	Charcoal	This paper
Ifri n'Ammar	level 25	UtC-6181	13 880	80	Charcoal	Moser 2003
Ifri n'Ammar	level 26	UtC-6180	13 590	70	Charcoal	Moser 2003
Ifri n'Ammar	level 23	UtC-6178	12 640	90	Charcoal	Moser 2003
Ifri n'Ammar	level 18	UtC-6177	12 480	80	Charcoal	Moser 2003
Ifri n'Ammar	level 18, hearth	UtC-6176	12 430	70	Charcoal	Moser 2003
Ifri n'Ammar	level 18	Erl-4407	12 384	100	Charcoal	Moser 2003
Ifri n'Ammar	level 15	Erl-4397	12 374	108	Charcoal	Moser 2003
Ifri n'Ammar	level 18, burial	Erl-4401	12 290	133	Charcoal	Moser 2003
Ifri n'Ammar	level 12	Erl-4406	11 949	105	Charcoal	Moser 2003
Ifri n'Ammar	level 16, burial	Erl-4400	11 853	105	Charcoal	Moser 2003
Ifri n'Ammar	level 10	UtC-6179	11 760	60	Charcoal	Moser 2003
Ifri n'Ammar	level 7, hearth	UtC-6175	11 670	60	Charcoal	Moser 2003
Ifri n'Ammar	level 14	UtC-6183	11 610	100	Charcoal	Moser 2003
Ifri n'Ammar	level 8	Erl-4395	11 595	103	Charcoal	Moser 2003
Ifri n'Ammar	level 10, burial	Erl-4398	11 526	110	Charcoal	Moser 2003
Ifri n'Ammar	level 9	Erl-4396	11 519	105	Charcoal	Moser 2003
Ifri n'Ammar	level 6	UtC-6182	11 370	70	Charcoal	Moser 2003
Ifri n'Ammar	level 11, burial	Erl-4399	11 009	144	Charcoal	Moser 2003
Ifri n'Ammar	level 4	Erl-4394	10 022	80	Charcoal	Moser 2003
Ifri Armas	Layer IV	Erl 12421	11 769	69	Bone	Lorenz 2010
Ifri Armas	Layer IV	Erl 12417	11 712	70	Bone	Lorenz 2010
Ifri Armas	Layer IV	KN-5970	11 475	85	Marine Shell	Lorenz 2010
Ifri Armas	Layer IV	Erl 13383	11 361	80	Charcoal	Lorenz 2010
Ifri Armas	Layer III	KN-5969	10 285	80	Marine Shell	Lorenz 2010
Hassi Ouenzga plein air	western profile	Bln-4756	10 570	177	Charcoal	Linstädter et al. 2012
Hassi Ouenzga plein air	level 11, No 50, 9.06 m	Erl-9990	12 424	87	Charcoal	Linstädter et al. 2012
Hassi Ouenzga plein air	level 6, No 18, 9.13 m	Erl-9991	10 130	68	Charcoal	Linstädter et al. 2012
Hassi Ouenzga plein air	level 4, No 9 ,9.26 m	Erl-9992	10 643	73	Charcoal	Linstädter et al. 2012

Appendix, Tab. 2. Radiocarbon dates from Iberomaurusian assemblages in the Eastern Rif (Morocco).

Appendix, Tab. 2. *Radiokohlenstoffdatierungen von Fundstellen des Ibéromaurusiens im östlichen Rif, Marokko.*

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