Uthmeier/Maier (Eds.) · STONE AGE. Papers in Honor of Jürgen Richter

Universitätsforschungen zur prähistorischen Archäologie

Band 396

Aus dem Institut für Ur- und Frühgeschichte
der Universität zu Köln

2024

Verlag Dr. Rudolf Habelt GmbH, Bonn

STONE AGE

Studying Technologies of Non-analogous Environments and Glacial Ecosystems

Papers in Honor of
Jürgen Richter

edited by
Thorsten Uthmeier & Andreas Maier

2024

Verlag Dr. Rudolf Habelt GmbH, Bonn

Satz und Layout: Anja Duwe
Coverdesign und Frontispize: Anja Duwe und Florian Sauer
Gesamtherstellung: Druckerei Martin Roesberg, Alfter-Impekoven

ISBN 978-3-7749-4427-5

Bibliografische Information der Deutschen Nationalbibliothek
Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detailliertere bibliografische Daten sind im Internet über ‹http://dnb.dnb.de› abrufbar

VORWORT
DER HERAUSGEBER*INNEN

Die Reihe „Universitätsforschungen zur prähistorischen Archäologie“ trägt dem Bedürfnis Rechnung, Examensarbeiten und andere Forschungsleistungen in die Öffentlichkeit zu tragen. Thematisch findet darin die ganze Breite des Faches vom Paläolithikum bis zur Archäologie der Neuzeit ihren Platz.
Ursprünglich hatten sich fünf Universitätsinstitute in Deutschland zur Herausgabe der Reihe zusammengefunden, der Kreis ist inzwischen deutlich größer geworden. Alle interessierten Professoren*innen und Dozent*innen sind eingeladen, als Mitherausgeber*innen tätig zu werden und Arbeiten aus ihrem Bereich der Reihe zukommen zu lassen. Für die einzelnen Bände zeichnen jeweils die Autor*innen und Institute ihrer Herkunft, die im Titel deutlich gekennzeichnet sind, verantwortlich. Sie erstellen eine druckfertig gestaltete Datei (PDF). Bei gleicher Anordnung des Umschlages haben die verschiedenen beteiligten Universitäten jeweils eine spezifische Farbe. Finanzierung und Druck erfolgen entweder durch sie selbst oder durch den Verlag Dr. Rudolf Habelt GmbH, der in jedem Fall den Vertrieb der Bände sichert.

Table of Contents

Preface XI

Vorwort XV

Tabula gratulatoria XIX

Africa 1

Lake sediments from Ethiopia: archives of environmental conditions in the habitat of our human ancestors
Seesedimente aus Äthiopien: Archive für Umweltbedingungen im Lebensumfeld unserer menschlichen Vorfahren
Frank Schäbitz, Asfawossen Asrat, Henry F. Lamb, Verena Foerster, Ralf Vogelsang & Martin H. Trauth 3

Twisted Bifaces from the Bilate River. Reduction Step Analysis of an Acheulean Assemblage from Ethiopia
Gedrehte rotationssymmetrische Faustkeile vom Bilate River. Gyrosymmetrische Arbeitsschrittanalysen an einem Inventar des Acheuléen aus Äthiopien
Christian Schepers 17

Lithics and landscapes – Middle Palaeolithic raw material resources in Wadi Qena/Egypt
Lithik und Landschaft – Mittelpaläolithische Rohstoffvorkommen im Wadi Qena/Ägypten
Karin Kindermann, Felix Henselowsky & Olaf Bubenzer 29

Das Later Stone Age von Etemba 14, Namibia: Techno-ökonomische Charakterisierung des Materials der Nachgrabung von 1984
The Later Stone Age of Etemba 14, Namibia: techno-economic characterisation of the material from the 1984 excavation
Isabell Schmidt & Götz Ossendorf 41

Marking a new territory – Hairline engravings in the Nuob Gorge/Namibia
Die Markierung eines neuen Lebensraumes – Haarlinien-Gravierungen in der Nuob Schlucht/Namibia
Ralf Vogelsang & Tilman Lenssen-Erz 55

New ways, new views. Recording rock art past and present - an example from the Erongo Mountains, Namibia
Neue Wege, neue Ansichten. Felsbilddokumentation damals und heute - ein Beispiel aus dem Erongo-Gebirge, Namibia
Peter Breunig & Gabriele Franke 67

A Paradise of Tools: Wadi Shaw 83/105 und die postglaziale Wiederbesiedlung der sudanesischen Westwüste
A Paradise of Tools: Wadi Shaw 83/105 and the postglacial reoccupation of Sudan's western desert
Jan Kuper 85

On the archaeological visibility of pastoral nomadic groups: the Handessi Horizon in the southern Libyan desert (North-Sudan)
Zur archäologischen Sichtbarkeit von pastoralen Normadengruppen: der Handessi Horizont in der südlichen Libyschen Wüste (Nord-Sudan)
Frederike Jesse 99

Middle Palaeolithic 115

The Palaeolithic archaeology of the Almonda karst system (Portugal): a window into half-a-million years of western Iberian prehistory
L'archéologie paléolithique du système karstique d'Almonda (Portugal) : une fenêtre sur un demi-million d'années de la préhistoire de l'Ibérie occidentale
João Zilhão 117

Filling the Middle Pleistocene gap: The Lower Palaeolithic site of Bunker (Stuttgart-Bad Cannstatt/ Germany)
Überbrückung der mittelpleistozänen Lücke: der altpaläolithische Fundplatz Bunker (Stuttgart-Bad Cannstatt/ Deutschland)
Berrin Çep & Yvonne Tafelmaier **135**

Neanderthals and the Sea
Les Néandertaliens et la mer
Pascal Depaepe **155**

The Late Pleistocene/Middle Palaeolithic mammalian fauna from Buhlen (Germany)
Die spätpleistozäne/mittelpaläolithische Säugetierfauna vom Buhlen (Deutschland)
Thijs van Kolfschoten **165**

Two low-density sites from the Lone Valley of SW-Germany and their implications for Middle Palaeolithic settlement dynamics
Zwei Fundstellen mit geringer Funddichte im Lonetal in SW-Deutschland und ihre Bedeutung für mittelpaläolithische Siedlungsdynamiken
Benjamin Schürch, Nicholas J. Conard **177**

New insights into the Middle Palaeolithic Bábonyian industry at the eponymous site, Sajóbábony-Méhész-tető (Hungary)
Nouveaux regards sur l'industrie bábonyienne du Paléolithique moyen sur le site éponyme, Sajóbábony-Méhész-tető (Hongrie)
Zsolt Mester & Agnès Lamotte **197**

Die Schäl Sick kommt. Zwei Paläolithische Steinartefakte im Kölner Stadtgebiet aus Dellbrück und Eil (Nordrhein-Westfalen, Deutschland)
The 'Schäl Sick' is coming. Two Palaeolithic Stone Artefacts in the Cologne City Area from Dellbrück and Eil (Northrhine-Westphalia, Germany)
Andreas Pastoors **215**

Upper Palaeolithic **227**

Identification of workpieces, transformation analysis, and the transition from the Middle to the Upper Paleolithic in the Northern Black Sea Region: the case of Buran-Kaya III, Level C (Crimea, Ukraine)
Rohmaterialsortierung, Transformations-Analyse und der Übergang vom Mittel- zum Jungpaläolithikum im nördlichen Schwarzmeergebiet: Buran-Kaya III, Level C (Krim-Halbinsel, Ukraine)
Thorsten Uthmeier **229**

Less is more: the elegance of the Ahmarian lithic production
Weniger ist mehr: die Eleganz der Steingeräteproduktion des Ahmarien
Jacopo Gennai **255**

Technological variability of the Eastern European Early Upper Palaeolithic
Technologische Variabilität im frühen Jungpaläolithikum Osteuropas
Guido Bataille **279**

What connects us? Riparian landscape use and mobility in Late Pleistocene East-Central Europe
Was verbindet uns? Die Nutzung von Flusslandschaften und Mobilität im Jung-Pleistozäns des zentralen Mitteleuropa
Wei Chu **299**

A meaningful prefix: the dawn of the Epigravettian in the East Carpathian area
Un préfix éloquent : le commencement de l'Épigravettien à l'Est des Carpathes
Mircea Anghelinu, Cristina Cordoș, Loredana Niță & Marc Händel **319**

Revision analysis of the Paleolithic lithic industry from the Močenok site on the lower stream of the Váh river (western Slovakia)
Neuanalyse der paläolithischen Steingeräteindustrie der Fundstelle Močenok am Unterlauf der Váh (westliche Slowakei)
Ľubomíra Kaminská & Adrián Nemergut **339**

Silex-Frauen-Figuren von Kammern-Grubgraben?
Female Silex figurines in Kammern-Grubgraben?
Christine Neugebauer Maresch & Michael Brandl **351**

Das Werkzeuginventar der Magdalénienfundstelle Bad Kösen-Lengefeld
The lithic tool inventory from the Magdalenian site of Bad Kösen-Lengefeld
Sebastian Szyja-Kollmann **363**

Holocene **373**

Auerochs hunting in the Niers valley near Mönchengladbach (Lower Rhine Embayment, western Germany) during the Early Mesolithic
Frühmesolithische Auerochsenjagd in der Niers-Aue bei Mönchengladbach (Niederrhein, westliches Deutschland)
Martin Heinen & Michael Baales **375**

Mesolithische Besiedlung und Rohstoffversorgung im Allgäu
Mesolithic settlement and raw material supply in the Allgau region
Werner Schön, Birgit Gehlen, Jehanne Affolter, Giuseppe Gulisano, Armin Guggenmos, Sigulf Guggenmos, Elena Maier, Jörg Schröppel & Thorsten Uthmeier **399**

Pottery raw materials as indicators for mobility and regional contacts of the Early Neolithic settlers from Cabecicos Negros (Vera, Almería, Spain)
Keramik-Rohmaterialien als Indikator für Mobilität und regionale Kontakte frühneolithischer Siedler aus Cabecicos Negros (Vera, Almería, Spanien)
Jörg Linstädter, Hiltrud Müller-Sigmund & Gerd-Christian Weniger **423**

Die Linienbandkeramik und die Neolithisierung am Nordrand der westfälischen Mittelgebirge
The Linear Pottery Culture and the Neolithization of the Northern edge of the Westphalian low mountain range
Hans-Otto Pollmann **443**

Some thoughts on risk management and resilience in early agrarian societies in Central Europe (c. 5,000–4,500 BCE)
Gedanken zu Risikomanagement und Resilienz in frühen Agrargesellschaften Mitteleuropas (c. 5.000–4.500 BCE)
Silviane Scharl, Astrid Stobbe, Manuel Broich, Hannah Lindemann, Nadine Nolde, Astrid Röpke, Anna Schick, Stefan Suhrbier & Tanja Zerl **457**

Denticulated sickle implements from Samreklo – particular finds from the South Caucasus
Gezähnte Sichel-Einsätze aus Samreklo – besondere Funde aus dem Süd-Kaukasus
Simone Arnhold & Utz Böhner **475**

Methods **487**

How to distinguish unfinished leaf points and bifacial knives? Testing theoretical assumptions on bifaces from Moravský Krumlov IV, Layer 0
Wie können Blattspitzen-Halbfabrikate von Keilmessern unterschieden werden? Eine Überprüfung theoretischer Annahmen am Beispiel von bifaziellen Stücke aus Moravský Krumlov IV, Layer 0
Małgorzata Kot & Petr Neruda **489**

Leaf points/bifacial tools: symbolic tools, weapons or something else? Some remarks on Moravian (Czech Republic) bifacial tools
Blattspitzen/bifazielle Geräte: symbolische Geräte, Waffen oder etwas anderes? Einige Anmerkungen zu bifaziellen Geräten aus Mähren (Tschechische Republik)
Zdeňka Nerudová **507**

Measuring true diversity – an application of the concept of Hill numbers on the example of site function in the Ahmarian
Das Messen der wahren Diversität – eine Anwendung des Konzeptes der Hill Zahlen auf das Beispiel der Siedlungsplatzfunktion im Ahmarian
Hannah Parow-Souchon **517**

Transformation analysis and systems-theory: from micro-scale lithic technical systems to macro-scale lithic ecosystems
Transformationsanalyse und Systemtheorie: Von kleinskaligen lithischen Einzelsystemen zu großskaligen lithischen Ökosystemen
Shumon T. Hussain **531**

Times of fast and slow change
Zeiten von schnellem und langsamem Wandel
Andreas Zimmermann **549**

Analysing "roughly coinciding boundaries" of cultural and natural phenomena
Analyse "grob vergleichbarer Grenzverläufe" kultureller und natürlicher Phänomene
Andreas Maier & Florian Sauer **569**

Heat altered phytoliths in the archaeological record
Hitzeveränderte Phytolithen im archäologischen Befund
Astrid Röpke, Barbara Eichhorn & Dagmar Fritzsch **579**

The other things – Pleistocene humans and the modern human athlete
Die anderen Dinge – Eiszeitliche Menschen und der moderne Athlet
Clemens Pasda **591**

Preface

Jürgen Richter and the Stone Age – A short academic biography

The contributions in this volume are all – in one way or the other – connected to Jürgen's biography and his broad research activities in different regions and periods of the Stone Age. This preface shall therefore sketch out a rough road map of his life to provide a background for the readers of this book. The authors are all linked to important steps of Jürgen´s career and include longstanding colleagues and many of his former students.

Jürgen was born in 1958 in Waldniel near Düsseldorf. Looking back, it seems like a twist of fate that his place of birth was so near to the site where little more than 100 years earlier the eponymous skeleton of the Neanderthals was found – the species that attracted much of Jürgen´s academic career and research. But we are getting ahead of us. Soon after his birth, he moved with his family to Erlangen, where his father worked as an engineer. Jürgen finished school in 1977 and one year later started studying Prehistoric Archaeology, Classical Archaeology and Art History at the Friedrich Alexander-Universität Erlangen-Nürnberg. Perhaps this came as a surprise to his family, since his two older brothers had chosen technical professions. However, archaeology was a successful choice from the start and Jürgen earned his Magister in 1983. Taken into consideration that soon after the start of his studies, Jürgen was so fascinated by the archaeology of the African continent that he took courses in Cologne, became a member of the Forschungsstelle Afrika and went to Namibia for fieldwork, he finished his Magister studies surprisingly fast. The fascination for the archaeology of Africa remained one major leitmotif of Jürgen´s work and academic career. In his PhD, he investigated stratigraphies with finds of Early Holocene hunter-gatherers from

Jürgen Richter during his excavation at the Magdalenian open-air site of Bad Kösen-Lengefeld.

Jürgen Richter während seiner Ausgrabungen an der Magdalénien-Freilandfundstelle Bad Kösen-Lengefeld.

Namibia. Not only did he analyse the lithic assemblages, but also ceramic finds, ostrich eggshells, and the artistic expressions from sites located in Twyfelfontein, the Messum crater, Spitzkoppe, and Erongo in the vicinity of the Brandberg massif. His studies of these sites cover a wide range of archaeological, environmental, ecological, and ethnographical perspectives. This interest in a holistic reconstruction of past lifeways was already coupled with an excellent methodological knowledge, a sense for details in the primary archaeological data, and a graphic talent. During this period, Jürgen intensively travelled through Africa and conducted fieldwork in Namibia, Egypt, and Sudan. It was the time of large-scale expeditions, who stayed in the desert for months and transported all equipment on off-road trucks. Like many other members of the Collaborative Research

Centre "Besiedlungsgeschichte der Ost-Sahara", Jürgen spent – if taken together – several years in Africa. Jürgen's archaeological research in Afrika thus provides the context for the contributions in the first section of this volume on topics such as lake sediments as environmental archives, Acheulean biface technology, Middle Stone Age raw material sources, Later Stone Age technology, rock art, postglacial resettlement of the desert, or Holocene pastoral nomadic groups.

Concerning research areas, Jürgen is a real globetrotter. With regard to his academic education, he was down-home. For his Magister as well as for his PhD, the Friedrich-Alexander-Universität Erlangen-Nürnberg was his *alma mater*. From an outside perspective, this might come as a surprise. The main reason for his long-term relation to the University at Erlangen – despite of his intensive scientific ties to Cologne – was his close professional and amicable bond to Prof. Gisela Freund. In Cologne, Jürgen had an equally close scientific and private friendship to Prof. Wolfgang Taute, the ordinarius at the Institute in Cologne – perhaps because both shared a great interest in the archaeology of Holocene hunter-gatherers and their small geometric tools. In 1988, Jürgen became assistant professor under his supervision. This is the biographic background for the book section dedicated to contributions on Holocene archaeology, covering topics such as Early Mesolithic Aurochs hunting, Mesolithic raw material supply in the Allgäu region, Neolithic pottery raw materials in Spain, the Neolithisation at the northern fringe of the Westphalian uplands, risk management and resilience in early agrarian societies, and Neolithic sickle implements from the Caucasus.

At the time, it was a common precondition for prehistoric archaeologists focusing on a career in academia to have expertise in a larger number of periods. After studying Holocene hunter-gatherers at the transition to farming and, less intensively, the Upper Palaeolithic materials from the Aurignacian site of Breitenbach during an internship at the Germanischen Nationalmuseum Nürnberg, Jürgen opted for a Middle Palaeolithic topic for his habilitation thesis, which he completed in 1995. It can be taken as a sign esteem that Gisela Freund offered him the artefact assemblage from the G-Layers-Complex of Sesselfelsgrotte in Bavaria. The topic was demanding, not only because of the about 85.000 lithic artefacts from stratigraphically challenging, densely packed archaeological layers, but also because of the question of the relation between the Mousterian and the Micoquian in Central Europe, which sprang from the interstratification of both complexes at Sesselfelsgrotte. Jürgen played out the methodological experiences he gained when working with the African material during his PhD and ingeniously solved both the stratigraphic difficulties and the chorological question by applying sophisticated quantitative methods and interpreting the results from the perspective of Neanderthal land use. The result was a brilliant habilitation thesis that challenged some commonplaces opinions on the Central European Middle Palaeolithic research. The newly developed perspective sees the Micoquian as a specific functional part of the Mousterian ("Mousterian with Micoquian option") instead of interpreting them as two independent industries. Bifacial pieces are seen as the expression of a dynamic tool concept instead of fixed and finite types ("bifacial tool families") identified by a specific protocol for working steep analysis. In addition, it became clear that the Micoquian existed not only in the Marine Isotope Stage 5, but also – and in Jürgen´s view exclusively – in Marine Isotope Stage 3. Jürgen's interest in methodological developments and open mindedness towards creative and unconventional approaches and ways of thinking about the Stone Age is the bracket for the section on methods of this volume. It contains contributions on options for distinguishing unfinished leaf points and bifacial knives, functional aspects of bifacial tools, options for measuring assemblage diversity, cultural macroevolution, how models of time influence our conception of the past, a method for comparing potentially recurring

boundary phenomena, heat altered phytoliths in the archaeological record, and implications for our understanding of Pleistocene humans when modern athletes are taken as a model.

After a prolongation of four years on the position as assistant professor, Jürgen started to apply for professorships. Given the low number of these positions in German speaking countries, this was not an easy task. The late 1990s thus were an eventful time with varying positions and phases of professional insecurity, but also with many academic merits. Between 1997–1998 he was Maître de Conférence at the Université Paris-Nanterre and was visiting professor in Frankfurt and Würzburg in 1999, and at the Université Royale de Phnom Penh in Cambodia in 1999 and 2000. Jürgen, who has always been interested in exploring cultural contexts formerly unknown to him, enjoyed these stays abroad despite of the all-day professional difficulties. After these chequered years followed a position as the head of the Forschungsstelle Afrika of the Cologne Institute for Prehistoric Archaeology. Whilst this enabled further activities in Africa, a successful application for a new project led him to another part of the world which he had not yet explored, the Ukraine. With the opportunity to study late Middle Palaeolithic sites on the Crimea, a novel important chapter in Jürgen´s research career began in 1999, with yearly research stays on the Peninsula until 2005. Jürgen's intensive occupation with Neanderthals during many periods of his career is the background for the section on the Middle Palaeolithic. It starts with contributions on the Lower Palaeolithic site of Bunker in Stuttgart Bad Cannstatt and a diachronous assessment of cultural developments from the Lower to the Middle Palaeolithic in the Almonda karst system in Portugal. Further, it unites research and reviews on Neanderthal seafaring, the Middle Palaeolithic mammalian fauna from Buhlen, settlement dynamics in the Lone valley, the Bábonyian industry at the eponymous site Sajóbábony-Méhész-tető in Hungary, and a working step analysis of artefacts from the city area of Cologne.

In 2002, Jürgen was appointed professor for the Palaeolithic at the University of Cologne. In parallel to his many international research projects, he intensified his investigations of sites in Germany. The search for underexplored areas near Cologne, already during his time as assistant professor, brought him to the region around Detmold. After several surveys and test excavations in Jerxen-Orpke and Pivitsheide, he found the important Late Palaeolithic site of Rietberg, where he excavated a large area over several years. The many years of intensive collaboration in Cologne during his time as assistant professor, scientist in the Collaborative Research Center "Besiedlungsgeschichte der Ost-Sahara", later as Principal Investigator in the Collaborative Research Centre "A.C.A.C.I.A", and eventually as full professor, allowed him to co-initiate a third Collaborative Research Centre "Our Way to Europe". Here, the many streams of his interests and former research areas merged: Central and Eastern Europe, Africa and Southwest Asia, late Neanderthals and early modern humans, the influence of human-environment interaction on human culture, and prehistoric land use. Jürgen became the speaker of this CRC and for twelve years was responsible for organising multi-disciplinary research on one of the hottest topics in Palaeolithic archaeology: the dispersal of modern humans from Afrika into Europe. The intensive cooperation between the Universities of Cologne, Aachen, and Bonn as well as between the archaeological and environmental disciplines had a long-lasting effect on the scientific landscape in the Rhineland. Several new professorships were created in Cologne and a new AMS-laboratory was built with participation of the archaeological sciences. Jürgen was not only PI of a number of projects within the CRC, but at the same time personally directed several field research projects in Ethiopia, where he was involved in the discovery of Lower Palaeolithic sites in high altitudes. In Jordan, he and his team discovered Early Upper Palaeolithic sites in the Wadi Sabra. From the excavations that lasted several years sprang – besides journal

publications – a number of student theses. In parallel, he managed to offer practical experience to a larger number of students in his excavations of the Magdalenian open-air site of Bad Kösen-Lengefeld near Naumburg. This site was and still is analysed in the framework of numerous theses. Therefore, this book also contains a section dedicated to the Upper Palaeolithic, including contributions on the Early Upper Palaeolithic in the Western Black Sea region, Ahmarian lithic technology, technological variability of the Eastern European Early Upper Palaeolithic, the role of rivers as corridors for human dispersal during the Aurignacian, the Eastern Gravettian, a Late Gravettian workshop in western Slovakia, potential female figurines made from flint, and thoughts on the lithic inventory of Bad Kösen-Lengefeld.

Many readers of this book know Jürgen first and foremost as a prehistoric archaeologist with an impressively broad scientific knowledge. More than a few will also have got to know him in field and laboratory projects as a dedicated promotor of young scientists with bountiful generosity in sharing resources and welcoming hospitality for guests from Germany and abroad. Apart from all that and his sustained enjoyment of travelling, he also has some hobbies, which have probably remained hidden to most people until now. The editors at least know about his interest in art, aquarelle painting, and collecting coins. Of course, he never had enough free time for them. He once said that the coins at home were the reason why he – unlike so many other archaeologists – has no collection of prehistoric finds although he likes to sort and classify things. We hope that he will still work in archaeology after his retirement. At the same time, we wish that he will also find some time for his coins.

Thorsten Uthmeier & Andreas Maier

Acknowledgements

The editors thank Anja Duwe very much for typesetting this book and for her patient editorial support. A big “thank you” also goes to Andrea Clements and Niko Niagkoules for their help with administration and accounting.

Vorwort

Jürgen Richter und die Steinzeit – Eine kurze akademische Biografie

Die Beiträge dieses Bandes haben alle auf die eine oder andere Weise mit Jürgens Biographie und seiner weit gefächerten Forschungstätigkeit in verschiedenen Regionen und Epochen der Steinzeit zu tun. Dieses Vorwort soll daher als Hintergrund für die Leserinnen und Leser dieses Buches Jürgen Richters Lebensweg grob skizzieren. Die Autorinnen und Autoren sind alle mit wichtigen Stationen in Jürgen Richters Lebensweg verbunden. Darunter sind langjährige Kolleginnen und Kollegen sowie viele seiner ehemaligen Schülerinnen und Schüler.

Jürgen Richter wurde 1958 in Waldniel in der Nähe von Düsseldorf geboren. Im Rückblick erscheint es wie eine Fügung des Schicksals, dass sein Geburtsort so nahe an dem Ort liegt, an dem etwas mehr als 100 Jahre früher das namensgebende Skelett des Neandertalers gefunden wurde – jener Spezies, die einen Großteil von Jürgen Richters akademischer Laufbahn und Forschung bestimmt hat. Aber wir greifen vor. Kurz nach seiner Geburt zog er mit seiner Familie nach Erlangen, wo sein Vater als Ingenieur arbeitete. Jürgen Richter machte 1977 sein Abitur und begann ein Jahr später sein Studium der Prähistorischen Archäologie, Klassischen Archäologie und Kunstgeschichte an der Friedrich-Alexander-Universität Erlangen-Nürnberg. Für seine Familie mag das eine Überraschung gewesen sein, denn seine älteren Brüder hatten beide technische Berufe gewählt. Die Archäologie erwies sich aber von Anfang an als richtige Wahl, und schon 1983 legte Jürgen Richter überaus erfolgreich seine Magisterprüfung ab. Wenn man bedenkt, dass er schon bald nach Beginn seines Studiums von der Archäologie des afrikanischen Kontinents so fasziniert war, dass er Kurse in Köln belegte, Mitglied der Forschungsstelle Afrika wurde und zu Feldforschungen nach Namibia ging, erfolgte der Studienabschluss erstaunlich zügig. Die Faszination für die Archäologie Afrikas blieb ein wichtiges Leitmotiv für Jürgen Richters Arbeit und wissenschaftliche Laufbahn. In seiner Dissertation untersuchte er Stratigraphien mit Funden frühholozäner Jäger und Sammler aus Namibia. Er analysierte nicht nur Steinwerkzeuge, sondern auch Keramikfunde, Straußeneischalen und Felskunst von Fundstellen aus Twyfelfontein, dem Messum-Krater, der Spitzkoppe und Erongo in der Nähe des Brandbergs. Seine Forschungen an diesen Fundstellen umfassen ein breites Spektrum unterschiedlicher archäologischer, ökologischer, umweltgeschichtlicher und ethnologischer Ansätze. Dieses ausgeprägte Interesse an einer ganzheitlichen Re-konstruktion vergangener Lebensweisen verband sich schon damals mit exzellenten methodischen Kenntnissen, einem Sinn für Details in den archäologischen Primärdaten und einem ungewöhnlichen graphischen Talent. In dieser Zeit bereiste Jürgen Richter intensiv dem Afrikanischen Kontinent und führte Feldforschungen in Namibia, Ägypten und im Sudan durch. Es war die Zeit der großen Expeditionen mit monatelangen Aufenthalten in der Sahara, bei denen die gesamte Ausrüstung auf geländegängigen Lastwagen transportiert wurde. Wie viele andere Mitglieder des DFG-Sonderforschungs-bereiches "Besiedlungsgeschichte der Ost-Sahara" verbrachte Jürgen Richter – wenn man alles zusammenzählt – mehrere Jahre in Afrika. Jürgen Richters archäologische Forschung in Afrika bildet den Kontext für die Beiträge im ersten Abschnitt dieses Bandes zu

Seesedimenten als Umweltarchiven, Biface-Technologien des Acheuléen, Rohstoffquellen des Middle Stone Age, Technologien des Later Stone Age, Felskunst, der postglazialen Wiederbesiedlung der Wüste oder Gruppen holozäner Pastoralnomaden.

Was seine Forschungsfelder betrifft, ist Jürgen Richter ein echter Weltenbummler – hinsichtlich seiner akademischen Ausbildung war er dagegen heimatverbunden. Sowohl für sein Magisterstudium als auch für seine Promotion war die Friedrich-Alexander-Universität Erlangen-Nürnberg seine Alma Mater. Das mag von außen betrachtet zunächst überraschen. Der Hauptgrund für seine langjährige Verbundenheit mit der Universität Erlangen war – trotz seiner intensiven wissenschaftlichen Kontakte nach Köln – eine enge berufliche und freundschaftliche Verbindung zu Prof. Gisela Freund. In Köln verband Jürgen Richter eine ebenso enge wissenschaftliche und private Freundschaft mit Prof. Wolfgang Taute, dem langjährigen Ordinarius des Kölner Instituts – vielleicht weil beide ein großes Interesse an der Archäologie holozäner Jäger-Sammler und ihren kleinen geometrischen Werkzeugen teilten. Im Jahre 1988 wurde Jürgen Richter Wolfgang Tautes wissenschaftlicher Assistent, damals als Akademischer Rat auf Zeit. Diesem biographischen Hintergrund sind Beiträge zur holozänen Archäologie in diesem Band gewidmet, die sich mit Themen wie der früh-mesolithischen Auerochsenjagd, der mesolithischen Rohstoffversorgung im Allgäu, keramischen Rohstoffen des Neolithikums in Spanien, der Neolithisierung am Nordrand des Westfälischen Berglandes, Risikomanagement und Resilienz in frühen Agrargesellschaften sowie neolithischen Sichelgeräten aus dem Kaukasus befassen.

Für prähistorische Archäologinnen und Archäologen, die im universitären System der 1990er-Jahre eine akademische Karriere anstrebten, war es üblich, sich in verschiedenen Perioden auszukennen. Nachdem er holozäne Jäger und Sammler am Übergang zum Ackerbau in Afrika und, weit weniger intensiv das jungpaläolithische Fundmaterial aus dem Aurignacien von Breitenbach während eines Praktikums im Germanischen Nationalmuseum Nürnberg untersucht hatte, wählte Jürgen Richter für seine 1995 abgeschlossene Habilitationsschrift ein mittelpaläolithisches Thema. Dass ihm Gisela Freund das Steinartefaktinventar aus dem G-Schichtkomplex der Sesselfelsgrotte in Bayern anbot, kann als Zeichen ihrer Wertschätzung aufgefasst werden. Das Thema war nicht nur wegen der ca. 85.000 lithischen Artefakte aus stratigraphisch schwierigen Schichten mit hoher Funddichte anspruchsvoll, sondern auch aufgrund der Frage nach dem Verhältnis zwischen dem Moustérien und Micoquien in Mitteleuropa, die sich aus der Interstratifikation beider Komplexe in der Sesselfelsgrotte ergab. Jürgen Richter nutzte die methodischen Erfahrungen, die er sich während seiner Doktorarbeit mit afrikanischem Material angeeignet hatte, und löste sowohl die stratigraphischen Schwierigkeiten als auch die chorologische Frage auf geniale Weise unter Einsatz quantitativer Methoden, deren Ergebnisse er aus der Perspektive der Landnutzungsmuster später Neandertaler-Gruppen interpretierte. Das Ergebnis ist eine brillante Habilitation, welche die bis dahin gängigen Forschungsmeinungen zum Mittelpaläolithikum in Mitteleuropa in Frage stellt. Anstatt sie als zwei unabhängige Industrien zu interpretieren, wird das Micoquien als funktional spezifischer Teil des Moustérien interpretiert (“Moustérien mit Micoque-Option”). Anstelle von finiten Typen sind die bifaziellen Werkstücke Ausdruck eines dynamischen Werkzeugkonzepts (“bifazielle Werkzeugfamilien”), die durch ein spezielles Protokoll der Arbeitsschrittanalyse identifiziert werden und bei längeren Aufenthalten vermehrt zur Ablage kommen. Zudem wird klar, dass das Micoquien nicht nur im Marinen Isotopenstadium 5, sondern auch – und nach Jürgen Richters Ansicht ausschließlich – im Marinen Isotopenstadium 3 existiert. Jürgen Richters Interesse an kreativen methodischen Entwicklungen und seine Aufgeschlossenheit gegenüber unkonventionellen Zugängen

zur Steinzeit bilden die Klammer für denjenigen Teil dieses Bandes, der sich mit archäologischen Methoden befasst. Er enthält Beiträge zu Unterscheidungsmöglichkeiten zwischen unfertigen Blattspitzen und bifaziellen Messern, zu funktionalen Aspekten bifazieller Werkzeuge, zu Möglichkeiten der Messung der Diversität von Inventaren, zu kultureller Makroevolution, zum Einfluss von Zeitmodellen auf unsere Vorstellungen von der Vergangenheit, zu einer Methode zum Vergleich potenziell wiederkehrender Grenzphänomene, zu thermisch veränderten Phytolithen in archäologischen Befunden und zu den Konsequenzen für unser Verständnis des pleistozänen Menschen, wenn moderne Athleten als Modell herangezogen werden.

Nach der Verlängerung seiner Assistenzzeit in Köln für weitere vier Jahre begann Jürgen Richter, sich auf Professuren zu bewerben. Angesichts der geringen Zahl solcher Stellen im deutschsprachigen Raum war dies kein leichtes Unterfangen. Die späten 1990er Jahre waren für Jürgen Richter eine ereignisreiche Zeit mit häufigen wechselnden akademischen Positionen und damit eine Phase beruflicher Unsicherheit, aber auch ein Lebensabschnitt mit zahlreichen akademischen Verdiensten. So war er 1997-1998 Maître de Conférence an der Université Paris-Nanterre, 1999 Gastprofessor in Frankfurt und Würzburg sowie 1999 und 2000 an der Université Royale de Phnom Penh in Kambodscha. Jürgen Richter, der sich schon immer für die Erkundung ihm unbekannter kultureller Kontexte interessierte, genoss diese Auslandsaufenthalte trotz der täglichen beruflichen Herausforderungen.

Nach bewegten Jahren wurde er dann Leiter der Forschungsstelle Afrika am Institut für Ur- und Frühgeschichte in Köln. Während diese Position weitere Aktivitäten in Afrika ermöglichte, führte ihn ein erfolgreicher Drittmittelantrag in einen anderen Teil der Welt, den er bis dahin noch nicht erforscht hatte, nämlich in die Ukraine. Mit der Möglichkeit, spätmittelpaläolithische Fundstellen auf der Krim zu untersuchen, begann 1999 ein neues, wichtiges Kapitel in Jürgen Richters Forscherkarriere mit jährlichen Aufenthalten auf der Halbinsel bis 2005. Seine intensive Beschäftigung mit Neandertalern während vieler Phasen seiner Karriere bildet den Hintergrund für den Abschnitt des vorliegenden Bandes, der nach Kapiteln zum späten Altpaläolithikum insbesondere Themen zum Mittelpaläolithikum im Vordergrund stehen. Der Teil beginnt mit Beiträgen zur altpaläolithischen Fundstelle Bunker in Stuttgart Bad Cannstatt und einer diachronen Betrachtung der kulturellen Entwicklungen vom Alt- zum Mittelpaläolithikum im Karstsystem von Almonda in Portugal. Darüber hinaus vereint es Untersuchungen und Übersichtsarbeiten zur Seefahrt der Neandertaler, zur mittelpaläolithischen Säugetierfauna von Buhlen, zur Siedlungsdynamik im Lonetal, zum Bábonyien an der Fundstelle Sajóbábony-Méhész-tető in Ungarn und eine Arbeitsschrittanalyse von Artefakten aus dem Kölner Stadtgebiet.

Seit 2002 ist Jürgen Richter Professor für Ältere Steinzeiten an der Universität zu Köln. Neben seinen zahlreichen internationalen Forschungsprojekten hat er auf dieser Stelle seine Forschungen zu Fundstellen in Deutschland intensiviert. So führte ihn die Suche nach einem Arbeitsgebiet in der Nähe von Köln bereits während seiner Assistenzzeit in den Raum Detmold, wo er nach Surveys und Probegrabungen in Jerxen-Orpke und Pivitsheide die bedeutende spätpaläolithische Fundstelle Rietberg über mehrere Jahre hinweg auf einer großer Fläche ausgegraben hat. Die langjährige intensive Zusammenarbeit mit zahlreichen Fachkolleginnen und -kollegen in seiner Zeit als Assistent, Mitarbeiter im DFG-Sonderforschungsbereich "B.O.S.", als Teilprojektleiter im Sonderforschungsbereich "A.C.A.C.I.A." und später als ordentlicher Professor in Köln ermöglichte es ihm, den dritten DFG-Sonderforschungsbereich mit Beteiligung des Kölner Institute, den SFB 806 "Unser Weg nach Europa", mit zu initiieren. Hier flossen die vielen Stränge seiner Interessen und bisherigen Forschungsgebiete zusammen: Mittel- und Osteuropa, Afrika und Südwestasien, späte Neandertaler und frühe moderne Menschen, der Einfluss

von Mensch-Umwelt-Interaktionen auf die menschliche Kultur sowie prähistorische Landnutzung. Jürgen Richter wurde Sprecher dieses SFBs und war zwölf Jahre lang verantwortlich für die Organisation der multidisziplinären Forschung zu einem der brennendsten Themen der altsteinzeitlichen Archäologie: der Ausbreitung des modernen Menschen von Afrika nach Europa. Die intensive Zusammenarbeit zwischen den Universitäten Köln, Aachen und Bonn sowie zwischen archäologischen und umweltwissenschaftlichen Disziplinen hat die Wissenschaftslandschaft im Rheinland nachhaltig geprägt. In Köln wurden unter Beteiligung der archäologischen Wissenschaften mehrere neue Lehrstühle eingerichtet und ein neues AMS-Labor aufgebaut. Jürgen Richter war nicht nur Sprecher des SFBs, sondern auch Leiter einer Reihe von Projekten, an deren Feldforschungsprojekten er regelmäßig teilnahm. So war er in Äthiopien an der Entdeckung altpaläolithischer Fundstellen in alpinen Höhen ebenso beteiligt wie in Jordanien an der Lokalisierung und Ausgrabung früh-jungpaläolithischer Fundstellen entlang des Wadi Sabra. Aus den mehrjährigen Grabungen gingen neben zahlreichen Fachpublikationen auch Abschlussarbeiten der beteiligten Studierenden hervor. Parallel dazu hat er bei den Ausgrabungen der Magdalénien-Freilandstation Bad Kösen-Lengefeld bei Naumburg einer großen Zahl von Studenten praktische Grabungserfahrungen vermittelt. Auch diese Fundstelle war und ist Gegenstand zahlreicher Abschlussarbeiten. Der vorliegende Band Buch enthält folgerichtig einen Abschnitt zum Jungpaläolithikum. Dieser umfasst Beiträge über das Frühe Jungpaläolithikum in der westlichen Schwarzmeerregion, zur Technologie des Ahmarian, zur technologischen Variabilität des Frühen Jungpaläolithikums in Osteuropa, zur Rolle von Flüssen als Korridore für die Ausbreitung des Menschen im Aurignacien, zum östlichen Gravettien, zu einem Werkplatz des späten Gravettien in der Westslowakei, zu möglichen Frauenfiguren aus Feuerstein sowie zu Überlegungen zum Steininventar von Bad Kösen-Lengefeld.

Vielen Leserinnen und Leser dieses Buches kennen Jürgen Richter in erster Linie als prähistorischen Archäologen mit einem beeindruckend breiten Wissen. Nicht wenige werden ihn darüber hinaus in Feld- und Laborprojekten als engagierten Förderer des wissenschaftlichen Nachwuchses kenngelernt haben, der bereitwillig seine Ressourcen teilt und gegenüber Kolleginnen und Kollegen aus dem In- und Ausland eine herzliche Gastfreundschaft an den Tag legt. Neben all dem und seiner nach wie vor anhaltenden Reiselust hat er aber auch einige Hobbys, die den allermeisten vermutlich bislang verborgen geblieben sind; wir als Herausgeber wissen zumindest, dass er sich für Kunst, Aquarellmalerei und das Sammeln von historischen Münzen interessiert. Jürgen hat einmal gesagt, dass die Münzen in seinem Haus der Grund dafür sind, dass er – im Gegensatz zu vielen anderen Archäologinnen und Archäologen – trotz einer großen Faszination für das Sammeln und Sortieren keine eigene Sammlung prähistorischer Funde besitzt. Wir hoffen, dass er auch nach seiner Pensionierung in der Archäologie tätig sein wird und wünschen ihm gleichzeitig, dass er daneben mehr Zeit für seine Münzen und andere Hobbies findet.

Thorsten Uthmeier & Andreas Maier

Danksagungen

Die Herausgeber bedanken sich sehr herzlich bei Anja Duwe für den Satz dieses Buches und die geduldige Unterstützung bei der Redaktion. Ein großes Dankeschön geht auch an Andrea Clements und Niko Niagkoules für Ihre Hilfe bei der Administration und Buchhaltung.

Tabula gratulatoria

Jehanne Affolter
Mircea Anghelinu
Asfawossen Asrat
Simone Arnhold
Michael Baales
Guido Bataille
Utz Böhner
Michael Brandl
Peter Breunig
Helmut Brückner
Olaf Bubenzer
Berrin Çep
Wei Chu
Erich Claßen
Nicholas J. Conard
Cristina Cordoș
Heinz-Werner Dämmer
Pascal Depaepe
Verena Förster
Gabriele Franke
Birgit Gehlen
Jacopo Gennai
Armin Guggenmos
Giuseppe Gulisano
Marc Händel
Martin Heinen
Felix Henselowsky
Rupert Housley
Shumon T. Hussain
Friederike Jesse
Ľubomíra Kaminská
Karin Kindermann
Mechthild Klamm
Eileen Kose
Małgorzata Kot
Inga Kretschmer
Jan Kuper
Henry F. Lamb
Agnès Lamotte
Frank Lehmkuhl
Jörg Linstädter
Andreas Maier
Elena Maier
Zsolt Mester
Jutta Meurers-Balke
Hiltrud Müller-Sigmund
Adrián Nemergut
Christine Neugebauer-Maresch
Petr Neruda
Zdeňka Nerudová
Loredana Niță
Götz Ossendorf
Hannah Parow-Souchon
Clemens Pasda
Andreas Pastoors
Astrid Röpke
Florian Sauer
Frank Schäbitz
Isabell Schmidt
Werner Schön
Jörg Schröppel
Benjamin Schürch
Sebastian Szyja-Kollmann
Yvonne Tafelmaier
Ursula Tegtmeier
Martin H. Trauth
Thorsten Uthmeier
Thijs Van Kolfschoten
Ralf Vogelsang
Gerd-Christian Weniger
João Zilhão
Andreas Zimmermann

The Palaeolithic archaeology of the Almonda karst system (Portugal): a window into half-a-million years of western Iberian prehistory

L'archéologie paléolithique du système karstique d'Almonda (Portugal) : une fenêtre sur un demi-million d'années de la préhistoire de l'Ibérie occidentale

João ZILHÃO[1]

[1]UNIARQ, Centro de Arqueologia da Universidade de Lisboa, Alameda da Universidade 1600-214 Lisboa, Portugal; email: joao.zilhao@campus.ul.pt; ORCID:https://orcid.org/0000-0001-5937-3061

Abstract - The spring of the Almonda River is associated with an extensive labyrinth of underground passages whose staggered disposition at different elevations of a 70 m-high escarpment reflects the incision of the region's hydrographic network. Over the last 500,000 years, the continued lowering of the phreatic level made the outlets associated with these passages available for human use. Eventually concealed by sediment accumulation and roof collapse, such cave entrances have since been rediscovered by systematic spalaeo-archaeological exploration. The ongoing excavation of these localities has shed light on the physical appearance, the stone tool technology, the lifeways, and the palaeoenvironmental background of the regional populations of the Lower, the Middle, and the Upper Palaeolithic. Key finds are the 400,000-year-old cranium from Gruta da Aroeira, which mixes traits previously thought to differentiate the Middle Pleistocene fossils of Europe at the species level, and the evidence for continued, controlled use of fire through the Middle Palaeolithic occupation of Gruta da Oliveira (c. 67.1–107.1 ka). The change through time observed in subsistence economies is parsimoniously explained by demographic increase and an attendant decrease in the size of the territories that individuals roamed across. This trend culminates in the Upper Magdalenian, which sees people focusing on a more limited range of large game and going down the food chain to regularly procure rabbits and river fish.

Résumée - *La source karstique de la rivière Almonda est associée à un labyrinthe de galeries souterraines dont la disposition échelonnée le long d'une falaise de 70 m d'hauteur réfléchit l'incision du réseau hydrographique régional depuis environ 500 000 ans. Certaines de ces galeries correspondent à d'anciens débouchés que la progressive descente du niveau phréatique a permis d'utiliser comme lieu d'habitat mais qui, jusqu'à leur redécouverte (par exploration spéléo-archéologique systématique du karst), resteraient cachées par l'accumulation de sédiments et l'écroulement des entrées. La fouille en cours de ces gisements a permis de documenter l'apparence physique, la technologie lithique, les modes de vie et les paléoenvironnements des populations qui ont habité la région pendant le Paléolithique inférieur, le Paléolithique moyen et le Paléolithique supérieur. Les plus importantes trouvailles concernent le crâne humain de la grotte de Aroeira, vieux de 400 000 ans et où l'on peut apprécier un mélange de traits précédemment utilisés pour différentier les fossiles du Pléistocène moyen d'Europe au niveau d'espèce, aussi bien que l'utilisation continue et contrôlée du feu à la grotte de Oliveira pendant le Paléolithique moyen, vers 67.1–107.1 ka. Les changements dans le temps long que l'on peut observer dans l'économie de subsistance peuvent être expliqués de manière parcimonieuse en tant que conséquence de l'augmentation de la densité du peuplement et de la diminution des territoires. Ce processus culmine au Magdalénien supérieur, moment auquel la gamme des herbivores chassés devient plus restreinte et l'exploitation des petites proies, lapins et poissons de rivière, joue un rôle important dans la subsistance.*

Keywords - Acheulean, Mousterian, Archaic humans, Neandertals, Solutrean, Magdalenian
Acheuléen, Moustérien, Hommes archaïques, Neandertaliens, Solutréen, Magdalénien

Introduction

The karst spring of the Almonda River opens at the foot of a c. 70 m-high cliff face. Locally known as Arrife do Almonda, this distinctive geographic feature is located about half-way through the c. 40 km-long, NE-SW-oriented fault escarpment that separates the Central Limestone Massif of Portuguese Estremadura from the Tertiary Basin of the Tagus, of which the Almonda is a tributary. Two major underground streams converge at the spring: the North River, which flows along the Vale da Serra synclinal through large, wide passages that can be accessed in the dry season, when the phreatic level is low; and the West River, which drains the Mira-Minde polje and flows through permanently inundated passages explored by scuba diving (Fig. 1A).

Above the current karst outlet, the progressive incision of the North River left behind a dense, labyrinthine system of dry passages. Unknown until about a century ago, their existence was first revealed when the adjacent paper mill began construction work to dam the spring for the production of electricity. A landslide generated by the detonation of explosives exposed a cave entrance located 5 m above the water level, which became known as Gruta da Nascente do Rio Almonda (Cave at the Spring of the Almonda River). It was here that the first archaeological exploration of the Almonda karst took place, under the direction of Afonso do Paço. This work revealed funerary usage during the Early Neolithic and the Bronze and Iron Ages (Paço et al. 1947, Guilaine & Ferreira 1970).

In the early 1970s, spelaeologists began mapping the Almonda karst's passages, which currently represent a cumulative extent of c. 12 km. In 1987, in the course of such work, members of STEA (Sociedade Torrejana de Espelologia e Arqueologia; Torres Novas Society for Spelaeology and Archaeology) discovered a few Solutrean points in a niche adjacent to Paço's trench (Maurício 1988). The following year, inaugurating decades of ongoing collaboration with STEA, I started a project designed to thoroughly explore the archaeology of that passage, since renamed to Galeria da Cisterna (Passage of the Cistern).

Over two field seasons (1988–89), my excavation of Cisterna provided data that have much enhanced our knowledge of the Holocene prehistory of the region (Carvalho 2007; Zilhão 2009, 2016, 2021; Zilhão & Carvalho 2011; Tente & Lourenço 2016; Zilhão et al. 2022) and clarified the nature of the passage's Upper Palaeolithic usage (Zilhão 1997; Trinkaus et al. 2011). This work was accompanied by the onset of a systematic spelaeo-archaeological exploration of the labyrinth above the spring, resulting in the location from the inside, at different elevations, of the rear end of a number of archaeologically fertile entrance deposits that eventual sedimentary fill-up, associated with roof collapse caused by the recession of the scarp face, had rendered invisible and undetectable from the outside (Zilhão et al. 1991, 1993).

Once relocated using geophysical methods (Carvalho & Veiga 1989), four of these new localities have been archaeologically explored: Gruta da Oliveira, Gruta da Aroeira, Gruta do Aderno, and Gruta do Pinheiro (all named after the largest tree or shrub growing from the rubble that concealed them – an olive tree, a lentisk, a broad-leaved phillyrea, and a pine, respectively; Fig. 1B). In the course of this work, a cave opening hanging c. 15 m above the water plane, atop a vertical face formed by the blasting that had revealed the opening to Cisterna, was reached by abseiling. Named Lapa dos Coelhos (Cave of the Rabbits) – after the surface finds made (bladelets and fossilised rabbit bones), which indicated the presence of a subsurface archaeological deposit of Palaeolithic age – this cavity was also included in the project.

Under the umbrella of my overall Almonda project, work at these sites was co-directed with a number of colleagues: Francisco Almeida, Ministry of Culture, Portugal, at Lapa dos Coelhos; Anthony E. Marks, Southern Methodist University, USA, and Victor P.

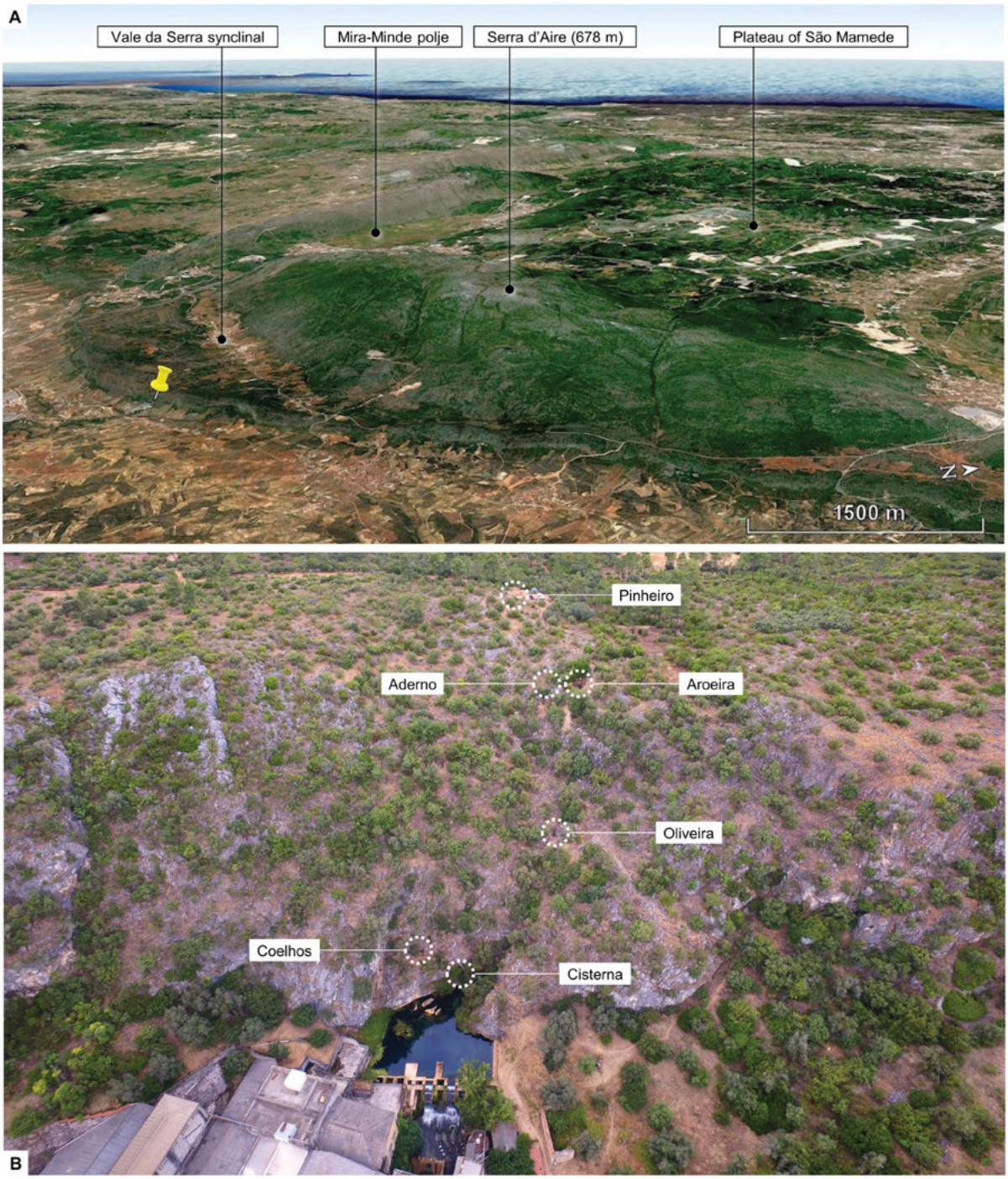
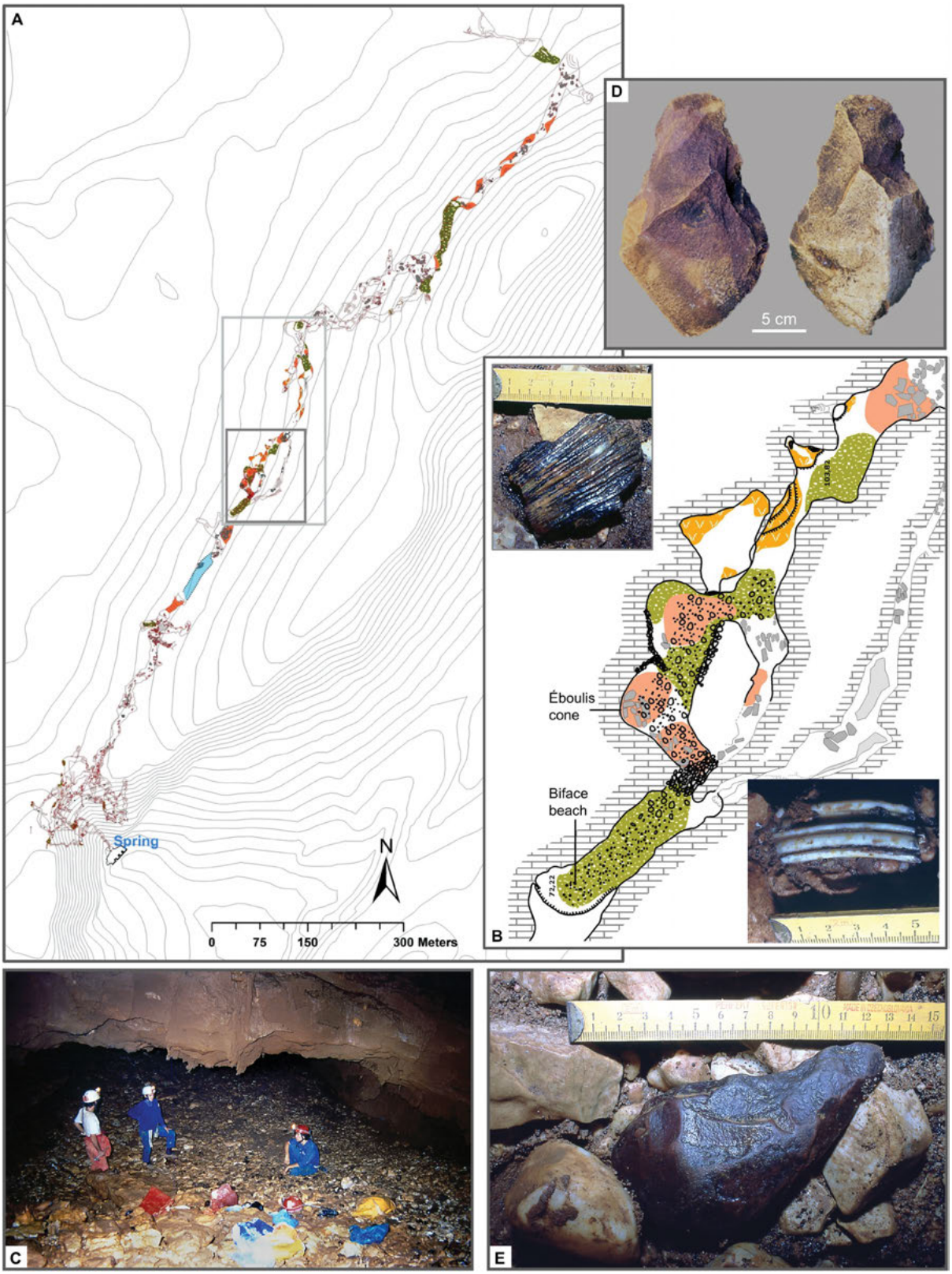


Fig. 1 Geographical location. (A) GoogleEarth view (2009-12-31; 1.5x elevation) of the Central Limestone Massif of Portuguese Estremadura (the yellow pin indicates the position of the Almonda spring). (B) Drone view of the Almonda escarpment (2016), with indication of the different archaeological sites discussed in the text (photo: Pedro Souto): Aroeira and Aderno – Acheulean; Pinheiro and Oliveira – Middle Palaeolithic; Coelhos – Upper Palaeolithic; Cisterna – Neolithic and Upper Palaeolithic.

Fig. 1 *Localisation géographique. (A) Vue GoogleEarth (2009-12-31; élévation 1,5x) du Massif calcaire central de l'Estrémadure portugaise (la punaise jaune indique la position de la source Almonda). (B) Vue par drone de l'escarpement d'Almonda (2016), avec indication des différents sites archéologiques évoqués dans le texte (photo: Pedro Souto): Aroeira et Aderno – Acheuléen ; Pinheiro et Oliveira – Paléolithique moyen ; Coelhos – Paléolithique supérieur ; Cisterna – Néolithique et Paléolithique supérieur.*

Chabaï, National Academy of Sciences, Ukraine, at Gruta da Aroeira (first phase); Joan Daura and Montserrat Sanz, University of Barcelona, Spain, at Gruta da Aroeira (second phase) and Gruta do Pinheiro; and Henrique Matias, University of Lisbon, at Gruta do



Aderno. Many others participated in the excavation work itself, or in the investigation and analysis of the finds. Among them is Jürgen Richter, who was involved in the initial rubble-removal and testing work carried out at Aroeira. On the occasion of his festschrift, it is therefore appropriate that my contribution consist of a synthesis of the last 35 years of

Fig. 2 The Entrada do Vale da Serra locality. (A) General map of the Almonda underground passages. The larger rectangle delimits the stretch of the North River between the Entrada do Vale da Serra artificial access and the first sump found upriver from the spring – the Galeria das Lâminas; the smaller rectangle delimits the area shown in (B), across which archaeological remains (including the elephant and horse teeth in the photo inserts, shown in situ at the time of discovery) are found in secondary position, both upriver and downriver (the Praia dos Bifaces locus) of the éboulis cone associated with an obturated shaft linking these passages with a sinkhole above. (C) The Praia dos Bifaces at the time of discovery (September 1989); the black items are manganese-coated quartzite objects (unmodified cobbles or artefacts). (D–E) Bifaces from the Praia dos Bifaces: non-patinated (D); edge-rounded and patinated, shown in situ at the time of discovery (E). Map and photos courtesy of STEA.

Fig. 2 *La localité Entrada do Vale da Serra. (A) Plan général des galeries karstiques associées au cours souterrain de l'Almonda. Le plus grand rectangle délimite le tronçon de la rivière Nord entre l'accès artificiel Entrada do Vale da Serra et le premier siphon trouvé en amont de la source – la Galeria das Lâminas; le plus petit rectangle délimite la zone indiquée en (B), à travers laquelle des vestiges archéologiques (dont les dents d'éléphant et de cheval dans les inserts photographiques, montrés in situ au moment de la découverte) se trouvent en position secondaire aussi bien en amont qu'en aval (dans le locus Praia dos Bifaces) du cône d'éboulis associé à l'aven obturé reliant ces passages à la doline au-dessus. (C) La Praia dos Bifaces au moment de la découverte (septembre 1989) ; les objets noirs sont des galets non modifiés ou des artefacts en quartzite enrobés de manganèse. (D–E) Bifaces de la Praia dos Bifaces: non patiné (D); bord arrondi et patiné, montré in situ au moment de la découverte (E). Carte et photos publiées avec l'aimable autorisation de STEA.*

Lower, Middle and Upper Palaeolithic research in the Almonda karst. For those who might wish to delve deeper into the archaeology of its different localities, I provide extensive referencing as we go along.

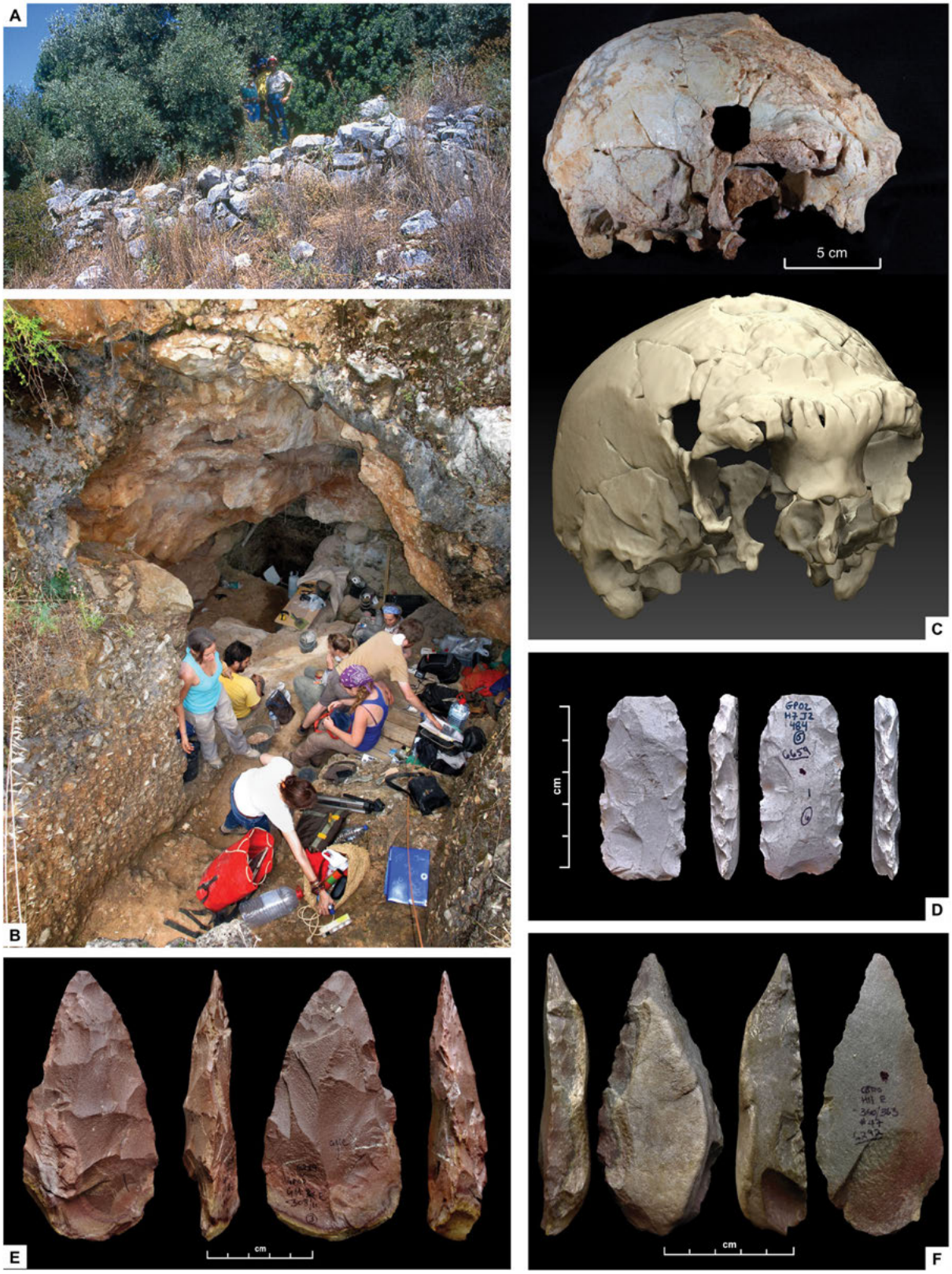
The Lower Palaeolithic

Identified in 1989, upon the opening by spelaeologists of the Entrada do Vale da Serra (Vale da Serra Entrance), an artificial access that bypassed a permanently inundated sump, the first locality of early Palaeolithic age found in the Almonda karst is located in the North River, c. 1 km upstream from the spring and c. 80 m below ground surface , in the Galeria das Lâminas (Passage of the Blades) (Fig. 2). This context consists of the secondary accumulation of a sand-and-gravel deposit swallowed down a vertical shaft situated at the bottom of a sinkhole. The karren-like depressions of the streambed partially retained the displaced deposit, whose components were subsequently dispersed by the regular, high-energy winter inundation of the passage – principally downstream, into the Praia dos Bifaces (Beach of the Bifaces) locus, but also upstream (Zilhão et al. 1991, 1993; see also Benson et al. 2021).

As a result of this formation process, the Entrada do Vale da Serra stone tools are patinated and feature edge- and ridge-rounding to degrees that vary with the intensity and frequency of their exposure to the running water. The assemblage is dominated by bifaces, almost entirely of quartzite, made on cobbles and large flakes (in 59% and 41%, respectively, of the cases for which blank identification remained possible) and ranging in length between 5.8 and 13.1 cm (Varanda 2017, 2020). The associated faunal remains consist of horse and ibex teeth as well as an unworn molar lamella assigned to *Elephas antiquus* (Cardoso 1996). Three of the horse teeth were dated by U-series and yielded ages between 136 ± 8 and 170 ± 13 ka (thousands of years ago) (Zilhão & Mckinney 1995). These results were calculated under early uptake assumptions and may well be minimum ages only.

Seventy metres above the spring, heavily brecciated Lower Palaeolithic archaeological deposits exposed by the recession of the scarp face were first identified at the Brecha das Lascas (Breccia of the Flakes) locus. Subsequent spelaeo-archaeological exploration revealed that this deposit lied in relation to two underground passage networks – the Galerias Pesadas ("Difficult" Passages) and the Galerias Leves ("Easy" Passages) – whose intersections with the extant slope form the two adjacent cave entrances of Aroeira and Aderno, respectively (Zilhão et al. 1991, 1993; Matias & Zilhão 2020) (Fig. 3).

In a first phase of work, between 1997 and 2002, the Aroeira interior was extensively excavated and a trench running parallel to the outcropping bedrock was opened at Brecha



das Lascas (Marks et al. 1999, 2002a, 2002b, 2005; Chabai et al., 2000–2001; Trinkaus et al. 2003). This work revealed an Acheulean context containing a rich faunal assemblage featuring a limited number of carnivore bones (dhole and bear), dominated by the remains of cervids and equids bearing cut-marks and other evidence of human modification, and

Fig. 3 The Gruta da Aroeira locality. (A–B) The cave: exterior view (A) of the concealed entrance taken in 1991, at the time of its geophysical detection, and overview (B), taken in 2014 from the same angle, of the reopened entrance during the second phase of excavation. (C) The Aroeira 3 cranium (fossil and virtual reconstruction) after (Daura et al. 2017a). (D–F). Stone tools from the Acheulean deposit. Photos: the author.

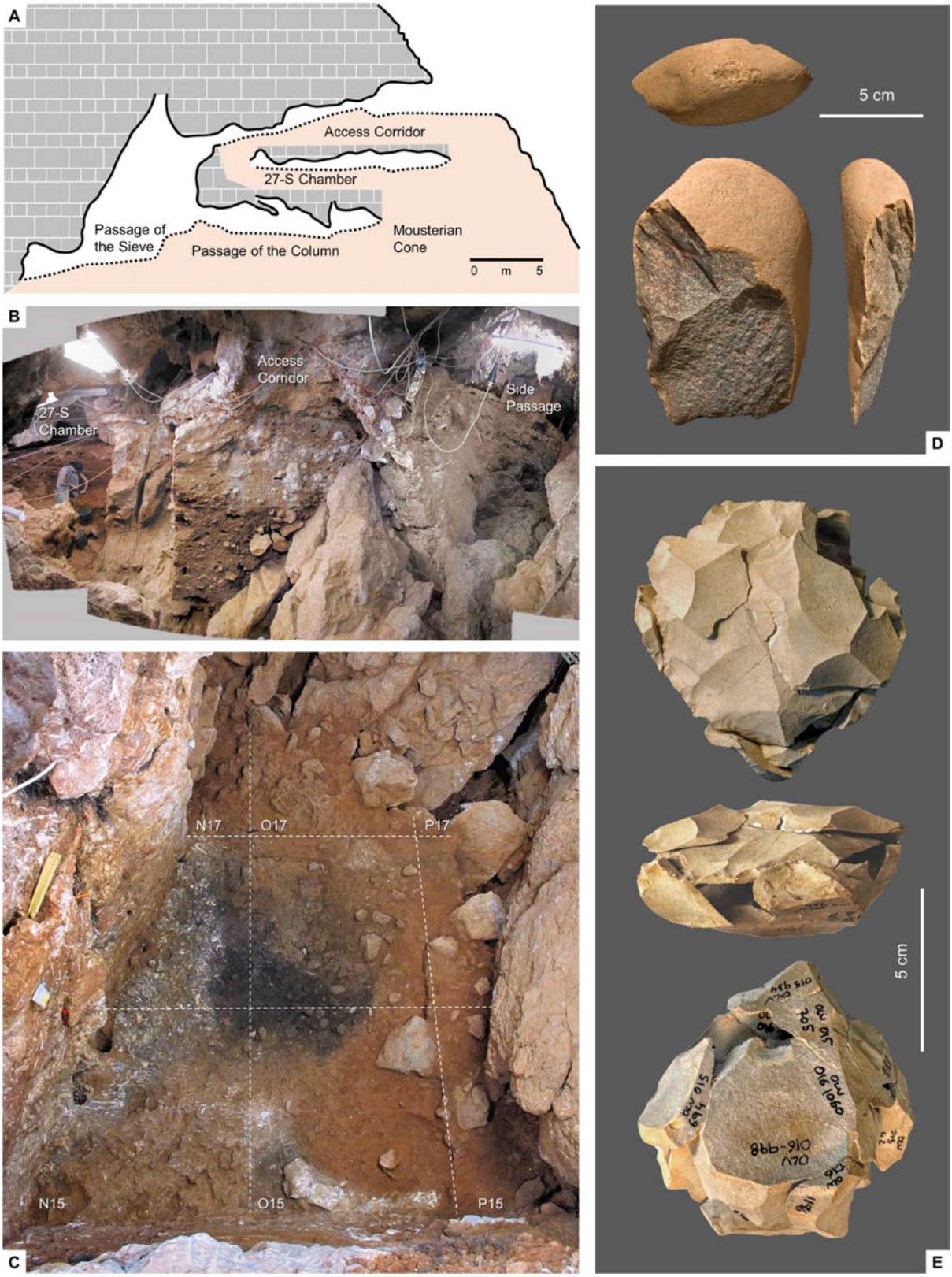
Fig. 3 *La localité Gruta da Aroeira. (A–B) La grotte: vue extérieure (A) de l'entrée cachée, prise en 1991, lors de sa détection géophysique, et vue d'ensemble (B), prise en 2014 sous le même angle, de l'entrée rouverte lors de la deuxième phase de fouille. (C) Le crâne Aroeira 3 (fossile et reconstruction virtuelle; d'après Daura et al. 2017a). (D–F) Outils lithiques des couches acheuléenes (photos: l'auteur).*

including rare taxa (such as *Macaca sylvanus* subsp. and *Praedama* cf. *savini*). Among the stone tools, mostly made on quartzite and quartz but also including some on chert and limestone, there are several handaxes and numerous sidescrapers, as well as bifacially worked pieces that have been compared with the keilmesser of the central European Micoquian. No cleavers were found, neither were any cores or flakes unambiguously demonstrative of Levallois reduction; besides bifacial shaping, the technological repertoire is limited to the production of flakes using the discoidal and sausage-slicing methods. Two associated human teeth, a lower canine and an upper third molar, were also retrieved. Subsequent U-series dating showed that the thick flowstone sealing this Acheulean context had formed between 326.4 ± 13.4 and 417.7/+37.3/-27.5 ka (2σ) (Hoffmann et al. 2013).

In a second phase, between 2013 and 2017 and starting from the level reached in the previous phase, the Aroeira infill was probed, across a limited area (6 m^2) at the back end of the cave interior that was fully capped by the dated flowstone (Daura et al. 2017a, 2017b, 2018, 2020; Conde-Valverde et al. 2018, 2020; López-García et al. 2018; Sanz et al. 2018; Alba et al. 2019; Croitor et al. 2019; Sanz et al. 2020; Cuenca-Bescós et al. 2021). Bedrock was eventually reached c. 3 m further down and U-series dating of the outer layer of a stalagmitic column covered by the Acheulean deposit constrained the latter's age to a maximum of 406 ± 30 ka (2σ). The stone tool assemblage retrieved during this phase of work was associated with the previously identified range of faunal remains and included another rare taxon – the *Haploidoceros mediterraneus* cervid – as well as burnt bones and additional evidence that fire had been used inside the cave. Albeit small (273 cores, flakes, and bifacial tools), this assemblage is technologically akin to the much more numerous lithics from the first phase, yielded use-wear evidence of woodworking, and contained cherts that, in those cases that could be provenanced, were found to come from sources in the Tagus basin to south and south-west.

The environment reconstructed from the microfauna is an open-woodland landscape developed under a mild climate featuring values slightly below present for mean annual temperature and mean temperature of the coldest month (1°C and a 2.8°C lower, respectively), and the interval (390–436 ka) that the U-series ages constrain the Acheulean of Aroeira to overlaps with the boundaries (396–426 ka) of MIS (Marine Isotope Stage) 11c. However, this long interglacial featured global average surface temperatures (GAST) up to 3°C higher than present (Snyder 2016), the deposit is a breccia of angular clasts suggestive of accumulation under cold climatic conditions, and the faunal list includes mountain taxa such as *Ovis antiqua* and cf. *Hemitragus* sp. that one would associate with rocky, largely denuded terrain. Most likely, therefore, it is the onset of the formation of the thick flowstone capping the Acheulean deposit that is the true marker for the early stages of MIS 11c at the site. If so, and bearing in mind the maximum age provided by U-series, the Acheulean of Aroeira would date to the last millennia of MIS 12 (426–436 ka), when the estimated GAST were c. 2°C below present (Snyder 2016), consistent with the climate and environment inferences derived from the microfauna.

The key find from the second phase of work at Aroeira is the partial Aroeira 3 human cranium. The fossil preserves most of the right half of a calvarium and a fragmentary



right maxilla with part of the nasal floor and two fragmentary molars. Taphonomic analyses noted bone loss in the frontal squama and the supraorbital arch and a perimortem bone fracture in the posterior region of the parietal bone but found no evidence of anthropogenic activity or of carnivore modification. Using symmetry, the braincase (except for the

Fig. 4 The Gruta da Oliveira locality. (A) Schematic section of the passages (after Zilhão et al. 2021b). (B–C) Overview of Side Passage (Divertículo Lateral) and September 27 Chamber (Sala 27 de Setembro) during the 2006 field season (B), and zenithal view of the Access Corridor (Corredor de Acesso) during the 2010 field season; the stratigraphic profile seen in (B) lies at the intersection between rows 18 and 19 of the grid and spans layers 7-16; the base of layer 21 and the hearth feature therein excavated are shown in (C). Photos: the author. (D) Cleaver from layer 19 (after Zilhão et al. 2021b ; photo, José Paulo Ruas). (E) Refit set R-2000 (Levallois core and 17 débitage products found in layer 21, distributed around the hearth seen in (C), after Deschamps & Zilhão 2018; photo, Marianne Deschamps).

Fig. 4 *La localité Gruta da Oliveira. (A) Coupe schématique des galieries (d'après Zilhão et al. 2021b). (B–C) Vue d'ensemble du Diverticule Latéral (Divertículo Lateral) et de la Salle du 27 Septembre (Sala 27 de Setembro) pendant la saison de terrain 2006 (B), et vue zénithale du Couloir d'Accès (Corredor de Acesso) pendant la saison de terrain 2010; le profil stratigraphique vu en (B) se situe à l'intersection des lignes 18 et 19 du carroyage et illustre la séquence de couches 7-16 ; la base de la couche 21 et le foyer creusé qui y a été fouillé sont représentés en (C). Photos: l'auteur. (D) Hachereau de la couche 19 (d'après Zilhão et al. 2021b ; photo, José Paulo Ruas). (E) Remontage R-2000 (nucléus Levallois et 17 produits de débitage trouvés dans la couche 21, répartis autour du foyer vu en (C), d'après Deschamps & Zilhão 2018; photo, Marianne Deschamps).*

occipital region) could be reconstructed virtually, enabling meaningful comparison with more complete coeval material from other European sites. That comparison revealed a combination of traits previously thought to discriminate between two different types of mid-Middle Pleistocene cranial morphologies: one, well represented by the Atapuerca sample, is Neandertal-like in the face, the supraorbital torus, the temporal bone, and the mandible, but not so much in the general shape of the neurocranium; the other, represented by the Arago 21 and Ceprano fossils, lacks any Neandertal-derived features. The supraorbital morphology of the Aroeira 3 cranium aligns it with the first group, while its well-developed angular torus and the projection of the mastoid process align it with the second group. This rather precisely dated fossil therefore augments the previously documented diversity of the Middle Pleistocene human fossil record and challenges interpretations of that diversity as expressing taxonomic distinction at the biological species level.

Work at Aderno was initiated in 2019. The current trench cuts back the profile that the previous work had left at Brecha das Lascas, progressing through the brecciated deposit towards a filled-up underground passage identified from the interior of the system in 2018 (and where, in contrast to Aroeira, the infill is not brecciated and can be excavated in regular archaeological manner). Below the flowstone providing the 417.7–27.5 (i.e., 390.2) ka terminus ante quem, the finds are consistent with the Acheulean assemblages found in the other loci of the Aroeira/Aderno site complex, but the small assemblage retrieved above is looking to be of Middle rather than Lower Palaeolithic affinities. This stratigraphic horizon was not represented in the 1997–2002 Brecha das Lascas trench and can be no older than the age – 278.5 + 12.7 (i.e., 291.2) ka – obtained for a stalagmite growing from the flowstone capping the Acheulean deposit.

The Middle Palaeolithic

Currently, only two Almonda localities are of well-established Middle Palaeolithic age, and both date to the latter part of the Last Interglacial complex, between the end of MIS 5c and the beginning of MIS 4: the caves sites of Pinheiro, and Oliveira. The former was excavated 2015–16 and is a hyaena den that yielded a large number of coprolites and hyaena-accumulated, fragmentary animal bones in incidental association with a small assemblage of stone tools of Middle Palaeolithic affinities (Daura et al. 2016) and probable early Upper Pleistocene age (Demuro and Arnold, personal communication). The latter features a 13 m-thick stratigraphic succession containing c. 6 m of archaeologically fertile deposits and was excavated between 1990 and 2012 (Zilhão et al. 1991, 1993, 2010, 2013, 2021b; Zilhão & Mckinney 1995; Marks et al. 2001; Trinkaus et al. 2007; Angelucci & Zilhão 2009; Nabais 2011, 2012; Badal et al. 2012; Willman et al. 2012; Hoffmann et al. 2013; Richter et al. 2014; Deschamps 2016; Matias 2016; Deschamps & Zilhão 2018; Zilhão & Angelucci 2018; Nabais & Zilhão 2019; López-García et

al. 2022; Angelucci et al. 2023; Linscott et al. 2023) (Fig. 4).

Oliveira is a former karst outlet located c. 40 m above the spring. OSL, TL and U-series dating constrain the archaeological sequence to the 67.1–107.1 ka interval: the upper part, layers 7–14, is of MIS 5a age, and the lower part, layers 15–25, is of MIS 5b age. This chronology is consistent with the paleoenvironment proxies – wood charcoal, small mammals – which indicate a climate colder than at present. In good agreement with the Greenland isotopic record, which shows that global climate went through a markedly cold spell at the end of MIS 5b (Rasmussen et al. 2014), a low is reached in layer 15, for which the microfauna-based, estimated drop in mean annual temperature is of 4–6°C. The deposit formed through the rhythmic alternation between pulses of accumulation, during stadials, and hiatuses in sedimentation (represented by the formation of carbonate crusts, including flowstones of variable thickness and extent), during interstadials. The hearth-burnt wood charcoal assemblages are dominated by Scots pine, while hazel, linden, and deciduous oaks, which are suggestive of thermophilous woodlands, were found in the pollen from e.g., the hyaena coprolites retrieved in layer 14. This pattern indicates an alternating use of the site by humans (during stadials) and carnivores (during interstadials), with the remains left behind by the latter on the stabilised cave floors becoming mixed with those accumulated in the preceding stadial as a result of post-depositional disturbance processes. Systematic intra- and inter-level stone tool refitting work has shown, however, that such processes had a limited impact in the stratigraphic integrity of the sequence, and the taphonomic analysis of the associated faunal remains (dominated by rhino, aurochs, horse, deer, ibex, and tortoise) indicates that they are anthropogenic for the most part.

The abundance of burnt bone documents use of fire in all units. In layers 14, 21 and 22, well-preserved hearth features were found in situ, documenting actual human presence in, and use of, the cave's interior. In other units (e.g., layers 16–19), the spatial distribution patterns suggest that occupation took place in the then-extant porch and that the archaeological remains found in the excavated area were syn-depositionally displaced by low-energy geological mechanisms (e.g., gravity and run-off). The >37,000-strong lithic assemblage is made on quartzite, quartz, and chert in comparable proportions, with chert predominating in the basal levels and quartzite in the upper ones. Levallois reduction was used throughout, complemented by other techniques, namely the Discoïd and Kombewa methods. The most conspicuous characteristic of this assemblage is the scarcity of formal (i.e., retouched) tools; sidescrapers and denticulates constitute most of the few that there are. Cleavers and bifaces exist, but they are limited to layers 15–19, suggesting that, during the Middle Palaeolithic of Iberia's west façade, such tools were in use only during a restricted period of time, c. 85.1–87.6 ka, at the very end of MIS 5b.

Fragmentary human skeletal remains, some bearing diagnostic Neandertal traits, were retrieved in layers 9, 10, 17, 18, 19 and 22. Most are hand and arm bones, but there are also three isolated teeth and a carnivore-chewed tibial diaphyseal fragment. Compared with a strontium isotope map of the region's soils, the high resolution record of variation in the $^{87}Sr/^{86}Sr$ ratio measured along the growth axis of the enamel of two human teeth from layer 22 has shown that, through the period of crown formation (between 3.5 and 14.5 years-old), the two individuals roamed across the sampled terrain. The observed values can be accounted for by a circular territory of c. 600 km^2 within which stays were short and residence moves were frequent. Encompassing both the lowlands of the Tagus basin and the highlands of the Central Limestone Massif, this model territory is consistent with the evidence derived from the sourcing of the cherts represented in the stone tool assemblage.

The Upper Palaeolithic

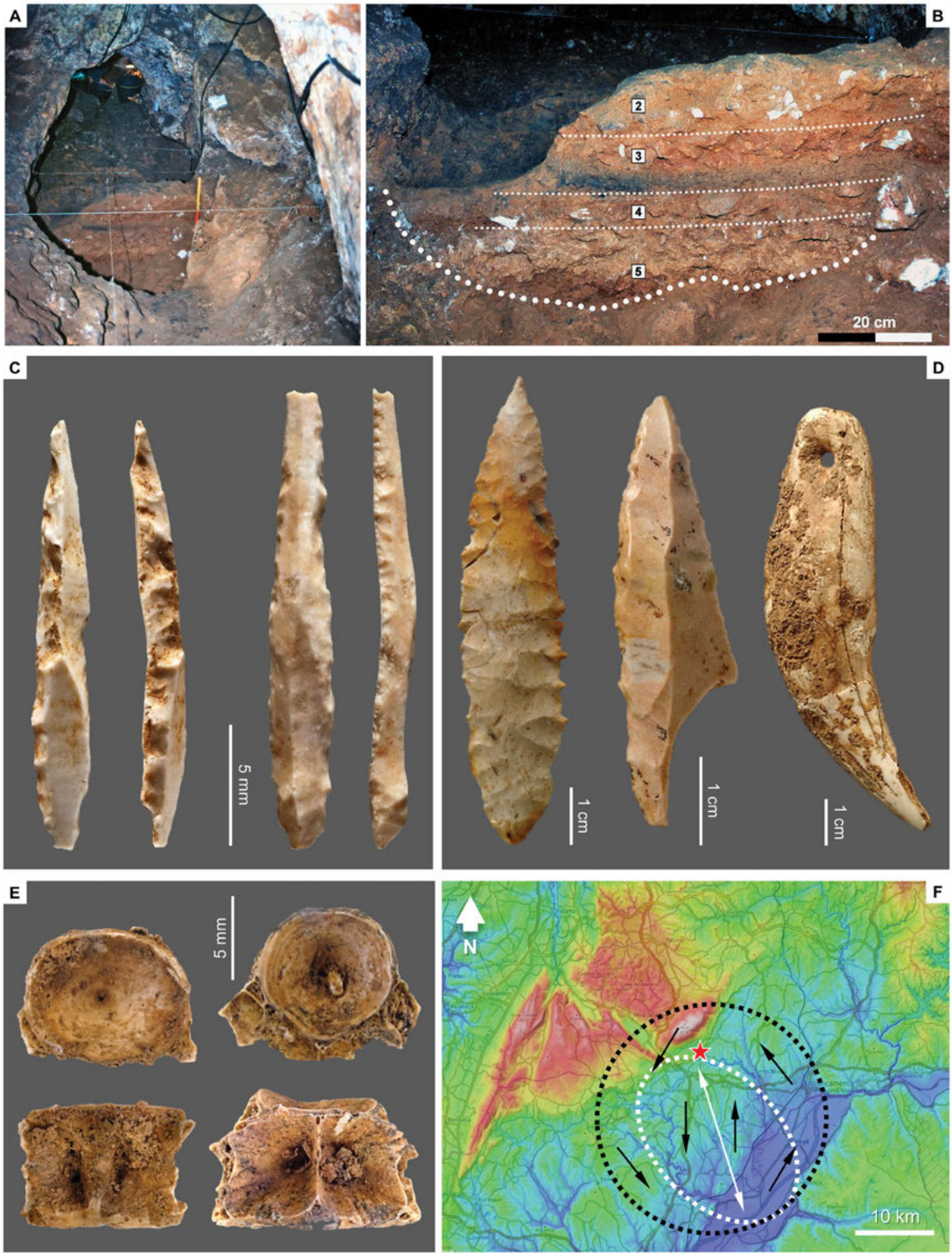
In the Almonda karst, the Upper Palaeolithic is represented at the cave site of Coelhos and the Cisterna passage (Fig. 5). In the latter, an assemblage of 15 laurel-leaves and shouldered points made of chert and jaspoïd slate has been interpreted as a cache; it was found in a very small area of brecciated sediment excavated in the same niche the points that triggered the Almonda project came from (Zilhão 1997). Equally scant evidence of human presence during the Solutrean, namely a laurel-leaf and a perforated bear canine, was also found in the basal units of the Coelhos sequence (Almeida et al. 2004).

The regional Upper Magdalenian is represented at Coelhos by layers 3 (dated to the 13.4–13.7 ka cal BP interval) and 4 (dated to the 13.8–14.8 ka cal BP interval) (Almeida et al. 2004; Gameiro & Almeida 2004; Gameiro 2007, 2012; Gameiro et al. 2008, 2017; Roselló-Izquierdo & Morales-Muñiz 2010; Vaz & Tereso 2021; Linscott et al. 2023). The latter's abundant wood charcoal assemblage is overwhelmingly dominated by Scots pine, suggesting persistence into the Bølling-Allerød interstadial of the open pine and heathland landscapes typical of western Iberia's LGM (Last Glacial Maximum) (Queiroz et al. 2002). The stone tool assemblages are microlithic and dominated by backed bladelets, although there are also a few endscrapers and burins. Abundant beads of perforated *Theodoxus* sp. and *Littorina* sp. shell were found in layer 3. Layer 4 yielded a small number of bone tools interpreted as fishhooks and numerous fish vertebrae – mostly freshwater cyprinids (e.g., *Barbus* sp.), but including *Salmo* sp. and *Alosa* sp. too. These fish bones corroborate the importance of small prey in the subsistence economy of the period, otherwise documented by the exploitation of rabbits, which comprise 94 to 96% of the mammal remains from both layers, among which red deer, ibex, and wild boar are also represented.

Layers 3–4 of a small, brecciated remnant preserved at Cisterna yielded a slightly later Upper Magdalenian occupation, which has been radiocarbon dated to 12.7–13.8 ka cal BP (Trinkaus et al. 2011; Linscott et al. 2023). In association with a limited number of stone tools and mammal remains in the range of the broadly coeval material from Coelhos, this remnant yielded a set of fragmentary human remains (a maxillary fragment, two isolated teeth, and three hand bones) belonging to at least three individuals: a young child, a late juvenile, and an adolescent or young adult. A high-resolution sequence of $^{87}Sr/^{86}Sr$ ratios measured along the growth axis of the enamel of a lower premolar representing the latter individual was analysed alongside the two Neandertal teeth from Oliveira. The Cisterna tooth revealed a pattern of repeated, probably seasonal alternation between two distinct strontium domains, one consistent with sediment values from the spring of the Almonda and the other consistent with values from the confluence with the Tagus. In good agreement with this pattern, it is in the Neogene terrain in between these two soil sampling localities that one finds the sources of c. 80% of the chert from the Magdalenian layers of Coelhos. The subsistence territory of the group the Cisterna individual belonged to can therefore be parsimoniously modelled as an elongated ellipse spanning the course of the Almonda along its right bank and over an area of c. 300 km^2.

Discussion and conclusions

For reasons that are bound to have climatic and geological underpinnings, all the stratigraphic successions of the Almonda karst so far fully known that are rich in archaeological remains – Aroeira, Oliveira, and Coelhos – would seem to have accumulated neither under full glacial nor under full interglacial conditions. The remains of beaver recovered in Aroeira, Oliveira and Cisterna indicate perennial running water through the interval of human occupation and the presence of a riparian forest along the course of the Almonda. The environments reconstructed from proxies tend to be



mosaic ones combining woodlands or open woodlands with prairie landscapes and mountain shrublands.

Across time, the most significant vector of change observed would seem to be the marked reduction in the diversity of the faunal assemblages. Among cervids, for instance, only red and roe deer persist into the Upper Pleistocene, while hyaena, rhino and tortoise are absent from the faunal

Fig. 5 The Galeria da Cisterna and Lapa dos Coelhos localities. (A-B) The AMD-1 zone of Galeria da Cisterna during the 1988 excavation (A) and stratigraphic profile of the Upper Magdalenian remnant that yielded the humans remains (B). Photos: the Author. (C) Microgravette points from Upper Magdalenian layer 4 of Lapa dos Coelhos (after Gameiro, 2012). (D) Solutrean artefacts from Galeria da Cisterna (laurel-leaf and backed-and-shouldered point) and Lapa dos Coelhos (perforated bear canine). Photos: José Paulo Ruas. (E) *Alosa* sp. (left) and *Barbus* sp. (right) vertebrae from Upper Magdalenian layer 4 of Lapa dos Coelhos. Photos: the author. (F) Model territories and mobility type inferred from strontium analysis of human teeth from the Middle Palaeolithic of Oliveira (black circle and black arrows) and the Upper Magdalenian of Cisterna (white ellipse and white arrows); the star denotes the position of the Almonda spring (modified from Linscott et al. 2023).

Fig. 5 *Les localités Galeria da Cisterna et Lapa dos Coelhos. (A-B) La zone AMD-1 de la Galeria da Cisterna lors de la fouille de 1988 (A) et profil stratigraphique du témoin du Magdalénien supérieur ayant livré les restes humains (B). Photos: l'auteur. (C) Microgravettes de la couche 4 du Magdalénien supérieur de Lapa dos Coelhos (d'après Gameiro 2012). (D) Artefacts solutréens de Galeria da Cisterna (feuille de laurier et pointe à dos et cran) et Lapa dos Coelhos (canine d'ours perforée). Photos: José Paulo Ruas. (E) Vertèbres d'Alosa sp. (à gauche) et de Barbus sp. (à droite) de la couche 4 du Magdalénien supérieur de Lapa dos Coelhos. Photos : l'auteur. (F) Territoires-modèle et types de mobilité déduits de l'analyse du strontium de dents humaines du Paléolithique moyen d'Oliveira (cercle noir et flèches noires) et du Magdalénien supérieur de Cisterna (ellipse blanche et flèches blanches) ; l'étoile indique la position de la source Almonda (modifié de Linscott et al. 2023).*

assemblages of Upper Palaeolithic age. These observations accord well the evidence from long, zooarchaeologically studied MIS 3-MIS 2 sequences elsewhere in the region, such as Gruta do Caldeirão (Davis 2002; Zilhão et al. 2021a) or the Lagar Velho rock-shelter (Moreno-García & Pimenta 2002; Almeida et al. 2009 ; Sanz et al. 2023).

This reduction in taxonomic diversity needs not imply a comparable reduction in the total biomass of the game that the subsistence of the region's Palaeolithic hunter-gatherers relied upon. Doubtless, the abundance of large herbivores is likely to have undergone long-term fluctuations as a result of changes in the amount of forest versus grass cover. However, such fluctuations do not suffice to explain why the Scots pine-and-heathland environments extant around the Almonda spring through both the Middle Palaeolithic of Oliveira and the Upper Magdalenian of Coelhos provided for quite distinct subsistence economies — ones based on the hunting of a wide range of large game in the case of the former, and ones focusing on deer, ibex, and small prey in the case of the latter.

One might be tempted to assign this difference to changes in human ability, for instance in relation to cognitive developments associated with the emergence of anatomical modernity (as proposed by e.g., Marean 2014). One might then speculate that, thanks to such developments, Upper Palaeolithic people possessed a more advanced knowledge of natural environments and more efficient extraction technologies, enabling the development of specialisation strategies that maximised the return on energy spent. However, recent discoveries have rendered untenable the notion that anatomically archaic humans of the Middle and early Upper Pleistocene (Neandertals and other early *Homo sapiens* such as those often grouped under the Linnean label of *H. heidelbergensis*) were categorically distinct in terms of cognition and language (Jaubert et al. 2016; Hoffmann et al. 2018a, 2018b; Zilhão 2020; Zilhão et al. 2020).

The change through time in subsistence economy revealed by the Almonda data can more promisingly be understood in light of two other facts: (a) the significant decrease in the size of subsistence territories suggested by the strontium evidence, which implies that, in the Upper Magdalenian, such territories had become half as large as they were during the Middle Palaeolithic, and (b) the fact that no remains of large carnivores have ever been found in post-LGM (Last Glacial Maximum) cave deposits, whether archaeological or palaeontological, of the Central Limestone Massif and adjacent areas – and this not just in the case of the hyaena (which by 35 ka would seem to have become extinct in the region) but also in the case of bear, leopard, or lion (Cardoso 1993).

I believe that the three observations above respond to a single underlying cause: demography. A significantly increased human population, implying more frequent visitation and use of the terrain surrounding

the Almonda spring, would have driven large carnivores away from the region. The need to feed more people from the same amount of animal biomass would in turn imply the need to go down the food chain. This is the more so bearing in mind the mosaic nature of the region's "neither-glacial-nor-interglacial" environments and the potential loss of access to certain types of niches entailed by a diminished subsistence territory. As otherwise intimated by the strontium data for the faunal remains of Oliveira and Cisterna that were analysed alongside the humans' (Linscott et al. 2023), this factor could explain why Upper Magdalenian Almondans focused on the ubiquitously available deer plus the ibex from the adjacent mountainous terrain and, quite unlike their predecessors, seemingly ignored horse and aurochs. The strontium values obtained for horses overlap with those for the Upper Magdalenian individual from Cisterna, and the taxon is well represented in the Solutrean of Coelhos and in the Middle Palaeolithic of Oliveira; yet, despite the similar environmental backdrop, they are absent from Almonda's Upper Magdalenian record. A parsimonious explanation is that horses preferred large riverside prairies such as found along the banks of the Tagus, ones that could well have lied beyond the boundaries of the subsistence territory of the spring's Upper Magdalenian people. This explanation is consistent with the fact that horses persisted in the region through the Pleistocene-Holocene transition, as shown by their presence among the faunal remains retrieved in the Mesolithic shell-middens of Muge, located c. 30 km downstream from the confluence between the Almonda and the Tagus (Lentacker 1986).

Hopefully, the results summarised here will have illustrated how the staggered disposition of the different Almonda localities provides for a rather unique opportunity to investigate half-a-million years of Palaeolithic prehistory simultaneously and under ceteris paribus conditions in terms of physical landscape and raw material sources. So far, the localities that it has been possible to explore archaeologically form a discontinuous record. There is every reason to believe that future research will fill the current gaps.

Acknowledgments

Over the years, the archaeological field work carried out in the Almonda karst benefited from financial and logistical support provided by a number of different institutions, primarily the following: Associação Arqueológica do Algarve, Câmara Municipal de Torres Novas, Instituto Português de Arqueologia, RENOVA – Fábrica de Papel do Almonda, Fundação para a Ciência e Tecnologia (projects PTDC/HIS-ARQ/098164/2008 and PTDC/HAR-ARQ/30413/2017), and Sociedade Torrejana de Espeleologia e Arqueologia.

References

Alba, D. M., Daura, J., Sanz, M., Santos, E., Yagüe, A. S., Delson, E. & Zilhão, J. (2019). New macaque remains from the Middle Pleistocene of Gruta da Aroeira (Almonda karst system, Portugal). *Journal of Human Evolution* 131: 40–47.

Almeida, F., Angelucci, D. E., Gameiro, C., Correia, J. & Pereira, T. (2004). Novos dados para o Paleolítico Superior final da Estremadura Portuguesa: resultados preliminares dos trabalhos arqueológicos de 1997–2003 na Lapa dos Coelhos (Casais Martanes, Torres Novas). *Promontoria* 2: 157–192.

Almeida, F., Moreno-Garciá, M. & Angelucci, D. E. (2009). From under the bulldozer's claws: the EE15 Late Gravettian occupation surface of the Lagar Velho rock-shelter. *World Archaeology* 41: 242–261.

Angelucci, D. E. & Zilhão, J. (2009). Stratigraphy and formation processes of the Upper Pleistocene deposit at Gruta da Oliveira, Almonda karstic system, Torres Novas, Portugal. *Geoarchaeology* 24: 277–310.

Angelucci, D. E., Nabais, M. & Zilhão, J. (2023). Formation processes, fire use, and patterns of human occupation across the Middle Palaeolithic (MIS 5a-5b) of Gruta da Oliveira (Almonda karst system, Torres Novas, Portugal). ***PLoS One*** 18(10): e0292075.

Badal, E., Villaverde, V. & Zilhão, J. (2012). Middle Palaeolithic wood charcoal from three sites in South and West Iberia: biogeographic implications. In: E. Badal, Y. Carrión, M. Macías & M. Ntinou (Eds.), *Wood and charcoal. Evidence for human and natural History*. Universitat de València, València, 13–24.

Benson, A., Hoffmann, D. L., Daura, J., Sanz, M., Rodrigues, F., Souto, P. & Zilhão, J. (2021). A speleothem record from Portugal reveals phases of increased winter precipitation in western Iberia during the Holocene. *The Holocene* 31: 1339–1350.

Cardoso, J. L. (1993). *Contribuição para o conhecimento dos grandes mamíferos do Plistocénico Superior de Portugal*, Oeiras, Câmara Municipal de Oeiras.

Cardoso, J. L. (1996). Nota sobre uma lamela de molar de elefante da gruta do Almonda (Torres Novas). *Comunicações do Instituto Geológico e Mineiro* 82: 169–174.

Carvalho, A. F. (2007). *A neolitização do Portugal meridional. Os exemplos do Maciço Calcário Estremenho e do Algarve ocidental*. Ph.D., Universidade do Algarve.

Carvalho, F. & Veiga, F. A. (1989). *O sistema SLOTER e a sua utilização na Gruta da Nascente do Almonda*, Coimbra, Centro de Investigação e Exploração Subterrânea.

Chabai, V. P., Sitlivy, V. I. & Marks, A. E. (2000–2001). Lower Paleolithic industry of Brecha das Lascas, level 7 (Portugal). *Préhistoire Européenne* 16–17: 17–41.

Conde-Valverde, M., Martínez, I., Quam, R., Arsuaga, J.-L., Daura, J., Sanz, M. & Zilhão, J. (2020). The cochlea of the Aroeira 3 Middle Pleistocene cranium – a comparative study. *Journal of Human Evolution*, 148, 102887.

Conde-Valverde, M., Quam, R., Martínez, I., Arsuaga, J.-L., Daura, J., Sanz, M. & Zilhão, J. (2018). The bony labyrinth in the Aroeira 3 Middle Pleistocene cranium. *Journal of Human Evolution* 124: 105–116.

Croitor, R., Sanz, M. & Daura, J. (2019). Deer remains from the Middle Pleistocene site of Gruta da Aroeira (Portugal): Iberian faunal endemism and implications for hominin paleobiogeography. *Quaternary Science Reviews* 225: 106022.

Cuenca-Bescós, G., Sanz, M., Daura, J. & Zilhão, J. (2021). The fossils of Castor fiber from the Middle Pleistocene site of Gruta da Aroeira (Portugal) and human-beaver interaction. *Quaternaire* 32: 1–10.

Daura, J., Sanz, M., Arsuaga, J. L., Hoffmann, D. L., Quam, R. M., Ortega, M. C., Santos, E., Gómez, S., Rubio, A., Villaescusa, L., Souto, P., Maurício, J., Rodrigues, F., Ferreira, A., Godhino, P., Trinkaus, E. & Zilhão, J. (2017a). New Middle Pleistocene hominin cranium from Gruta da Aroeira (Portugal). *Proceedings of the National Academy of Sciences* 114: 3397.

Daura, J., Sanz, M., Arsuaga, J. L., Quam, R. M., Hoffmann, D. L., Ortega, M. C., Santos, E., Gómez, S., Rubio, Á., Villaescusa, L., Souto, P., Rodrigues, F., Maurício, J., Ferreira, A., Godinho, P., Trinkaus, E. & Zilhão, J. (2017b). O crânio humano acheulense do Plistocénico Médio da Gruta da Aroeira. *In*: J. M. Arnaud & A. Martins (Eds.), *Arqueologia em Portugal 2020 – Estado da Questão*. Lisboa: Associação dos Arqueólogos Portugueses.

Daura, J., Sanz, M., Deschamps, M., Matias, H., Igreja, M., Villaescusa, L., Gómez, S., Rubio, A., Souto, P., Rodrigues, F. & Zilhão, J. (2018). A 400,000-year-old Acheulean assemblage associated with the Aroeira-3 human cranium (Gruta da Aroeira, Almonda karst system, Portugal). *Comptes Rendus Palevol* 17: 594–615.

Daura, J., Sanz, M., Rodrigues, F., Souto, P. & Zilhão, J. (2020). O sítio acheulense do Plistocénico Médio da Gruta da Aroeira. *In*: J. M. Arnaud, C. Neves & A. Martins (Eds.), *Arqueologia em Portugal 2020 – Estado da Questão*. Associação dos Arqueólogos Portugueses, Lisboa, 693–702.

Daura, J., Sanz, M. & Zilhão, J. (2016). *Gruta do Pinheiro. Relatório dos trabalhos arqueológicos de 2016*. Unpublished, on file at Direcção-Geral do Património Cultural.

Davis, S. J. M. (2002). The mammals and birds from the Gruta do Caldeirão, Portugal. *Revista Portuguesa de Arqueologia* 5: 29–98.

Deschamps, M. (2016). Traditions techniques dans les sociétés néandertaliennes du sud-ouest de l'Europe: continuités et ruptures dans les industries lithiques de la Gruta da Oliveira (Portugal). *Annales de la Fondation Fyssen* 31: 160–178.

Deschamps, M. & Zilhão, J. (2018). Assessing site formation and assemblage integrity through stone tool refitting at Gruta da Oliveira (Almonda karst system, Torres Novas, Portugal): A Middle Paleolithic case study. *PLoS ONE* 13(2): e0192423.

Gameiro, C. (2007). Bladelet debitage and microlith production during the Portuguese Tardiglacial. Presentation of a program for the revision of the available data. *In: From the Mediterranean basin to the Portuguese Atlantic Shore: Papers in Honor of Anthony Marks. Actas do IV Congresso de Arqueologia Peninsular*. Universidade do Algarve, Faro. 173–184..

Gameiro, C. (2012). *La variabilité régionale des industries lithiques de la fin du Paléolithique supérieur au Portugal*. PhD, Université Paris I – Panthéon-Sorbonne.

Gameiro, C. & Almeida, F. (2004). A ocupação da camada 3 da Lapa dos Coelhos (Casais Martanes, Torres Novas). Novos elementos sobre a produção de suportes lamelares durante o Magdalenense Final da Estremadura Portuguesa. *Promontoria* 2: 193–238.

Gameiro, C., Aubry, T. & Almeida, F. (2008). L'exploitation des matières premières lithiques au Magdalénien final en Estremadure portugaise: Données sur les sites de Lapa dos Coelhos et de l'Abri 1 de Vale dos Covões. *In*: Aubry, T., F. Almeida, A. C. Araújo, & M. Tiffagom (Eds.), *Space and Time: Which Diachronies, Which Synchronies, Which Scales?* Archaeopress, Oxford, 57–68.

Gameiro, C., Davis, S. & Almeida, F. (2017). A sequência estratigráfica da Lapa dos Coelhos: funcionalidade e subsistência ao longo do Pleistocénico Superior no sopé na Serra de Aire (Portugal). *In*: J. M. Arnaud & A. Martins (Eds.), *Arqueologia em Portugal. 2017 - Estado da Questão*. Associação dos Arqueólogos Portugueses, Lisboa, 357–374 .

Guilaine, J. & Veiga Ferreira, O. (1970). Le Néolithique ancien au Portugal. *Bulletin de la Société Préhistorique Française* 67: 304–332.

Hoffmann, D. L., Pike, A. W. G., Wainer, K. & Zilhão, J. (2013). New U-series results for the speleogenesis and the Palaeolithic archaeology of the Almonda karstic system (Torres Novas, Portugal). *Quaternary International* 294: 168–182.

Hoffmann, D. L., Angelucci, D. E., Villaverde, V., Zapata, J. & Zilhão, J. (2018a). Symbolic use of marine shells and mineral pigments by Iberian Neandertals 115,000 years ago. *Science Advances* 4: eaar5255.

Hoffmann, D. L., Standish, C. D., García-Diez, M., Pettitt, P. B., Milton, J. A., Zilhão, J., Alcolea-González, J. J., Cantalejo-Duarte, P., Collado, H., de Balbín, R., Lorblanchet, M., Ramos-Muñoz, J., Weniger, G.-C. & Pike, A. W. G. (2018b). U-Th dating of carbonate crusts reveals Neandertal origin of Iberian cave art. *Science* 359: 912–915.

Jaubert, J., Verheyden, S., Genty, D., Soullier, M., Cheng, H., Blamart, D., Burlet, C., Camus, H., Delaby, S., Deldicque, D., Edwards, R. L., Ferrier, C., Lacrampe-Cuyaubère, F., Lévêque, F., Maksud, F., Mora, P., Muth, X., Régnier, E., Rouzaud, J. N. & Santos, F. (2016). Early Neanderthal constructions deep in Bruniquel Cave in southwestern France. *Nature* 534: 111–114.

Lentacker, A. (1986). Preliminary results of the fauna of Cabeço de Amoreira and Cabeço de Arruda (Muge, Portugal). *Trabalhos de Antropologia e Etnologia* 26: 9–26.

Linscott, B., Pike, A. W. G., Angelucci, D. E., Cooper, M. J., Milton, J. A., Matias, H. & Zilhão, J. (2023). Reconstructing Middle and Upper Palaeolithic human mobility in Portuguese Estremadura through laser ablation strontium isotope analysis. *Proceedings of the National Academy of Sciences* 120: e2204501120.

López-García, J. M., Blain, H.-A., Sanz, M., Daura, J. & Zilhão, J. (2018). Refining the environmental and climatic background of the Middle Pleistocene human cranium from Gruta da Aroeira (Torres Novas, Portugal). *Quaternary Science Reviews* 200: 367–375.

López-García, J. M., Fagoaga, A., Nabais, M., Póvoas, L. & Zilhão, J. (2022). Late Quaternary (MIS 5a-5b) climate and environments of western Iberia inferred from the small-mammal assemblage of Gruta da Oliveira, Torres Novas, Portugal. *Palaeogeography, Palaeoclimatology, Palaeoecology* 603: 111194.

Marean, C. W. (2014). The origins and significance of coastal resource use in Africa and Western Eurasia. *Journal of Human Evolution* 77: 17–40.

Marks, A. E. (2005). Micoquian elements in the Portuguese Middle Pleistocene: assemblages from the Galeria Pesada. *In*: Bicho, N. & M. S. Corchón (Eds.), *Actas do IV Congresso de Arqueologia Peninsular (Faro, 14–19 de Setembro de 2004). 0 Paleolítico*. Universidade do Algarve, Faro, 195–206.

Marks, A. E., Monigal, K. & Chabai, V. P. (1999). Report on the initial excavations of Brecha das Lascas and Galeria Pesada (Almonda, Portuguese Estremadura). *Journal of Iberian Archaeology* 1: 237–250.

Marks, A. E., Brugal, J.-P., Chabai, V. P., Monigal, K., Goldberg, P., Hockett, B., Peman, E., Elorza, M. & Malloll, C. (2002a). Le gisement pléistocène moyen de Galeria Pesada (Estrémadure, Portugal) : premiers résultats. *Paléo* 14: 77–100.

Marks, A. E., Monigal, K., Chabai, V. P., Brugal, J.-P., Goldberg, P., Hockett, B., Peman, E., Elorza, M. & Malloll, C. (2002b). Excavations at the Middle Pleistocene Cave site of Galeria Pesada, Portuguese Estremadura: 1997–1999. *O Arqueólogo Português* IV-20: 7–38.

Marks, A. E., Monigal, K. & Zilhão, J. (2001). The lithic assemblages of the Late Mousterian at Gruta da Oliveira, Almonda, Portugal. *In*: Zilhão, J., Aubry, T. & A. F. Carvalho (Eds.), L*es premiers hommes modernes de la Péninsule Ibérique, Colloque de la Comission VIII de l'UISPP, Vila Nova de Foz Côa, Octobre 1998*. Instituto Português de Arqueologia, Almonda, Portugal, Lisboa, 145–154.

Matias, H. (2016). Raw material sourcing in the Middle Paleolithic site of Gruta da Oliveira (Central Limestone Massif, Estremadura, Portugal). *Journal of Lithic Studies* 3: 541–560.

Matias, H. & Zilhão, J. (2020). *Rede Cársica da Nascente do Almonda. Gruta do Aderno. Relatório de escavação 2019*. Unpublished, on file at Direcção-Geral do Património Cultural.

Maurício, J. (1988). Contribuição para o conhecimento da Pré-História de Torres Novas. *Almondinha* 2: 6–9.

Moreno-García, M. & Pimenta, C. M. (2002). The Paleofaunal Context. *In*: Zilhão, J. & E. Trinkaus (Eds.), *Portrait of the Artist as a Child. The Gravettian Human Skeleton from the Abrigo do Lagar Velho and its Archeological Context*. Instituto Português de Arqueologia, Lisboa, 112–151.

Nabais, M. (2011). The Neanderthal occupation of Gruta da Oliveira (Almonda karstic system, Torres Novas, Portugal). Analysis of the burnt bones. *Actas de las II Jornadas de Jóvenes en Investigación Arqueológica (Madrid, 6, 7 y 8 de mayo de 2009)*. Libros Pórtico, Zaragoza, 381–386.

Nabais, M. (2012). Middle Palaeolithic Tortoise Use at Gruta da Oliveira (Torres Novas, Portugal). *In*: Cascalheira, J. & C. Gonçales (Eds.), A*ctas das IV Jornadas de Jovens em Investigação Arqueológica - JIA 2011*. Universidade do Algarve, Faro, 251–258.

Nabais, M. & Zilhão, J. (2019). The consumption of tortoise among Last Interglacial Iberian Neanderthals. *Quaternary Science Reviews* 217: 225–246.

Paço, A., Vaultier, M. & Zbyszewski, G. (1947). Gruta da Nascente do Rio Almonda. *Trabalhos de Antropologia e Etnologia* XI: 171–187.

Queiroz, P. F., Mateus, J. E. & van Leeuwaarden, W. (2002). The Paleovegetational Context. *In*: Zilhão, J. & E. Trinkaus (Eds.), *Portrait of the Artist as a Child. The Gravettian Human Skeleton from the Abrigo do Lagar Velho and its Archeological Context*. Instituto Português de Arqueologia, Lisboa, 92–111.

Rasmussen, S. O., Bigler, M., Blockley, S. P., Blunier, T., Buchardt, S. L., Clausen, H. B., Cvijanovic, I., Dahl-Jensen, D., Johnsen, S. J., Fischer, H., Gkinis, V., Guilleviv, M., Hoek, W. Z., Lowe, J. J., Pedro, J. B., Popp, T., Sseierstad, I. K., Steffensen, J. P., Svensson, A. M., Vallelonga, P., Vinther, B. M., Walker, M. J. C., Wheatley, J. J. & Winstrup, M. (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.

Richter, D., Angelucci, D. E., Dias, M. I., Prudêncio, M. I., Gouveia, M. A., Cardoso, G. J., Burbridge, C. I. & Zilhão, J. (2014). Heated flint TL-dating for Gruta da Oliveira (Portugal): dosimetric challenges and comparison of chronometric data. *Journal of Archaeological Science* 41: 705–715.

Roselló-Izquierdo, E. & Moralez-Muñiz, A. (2010). Lapa dos Coelhos: informe sobre los restos de peces. *In*: A. Mata (Ed.), *Cuaternario y Arqueología: homenaje a Francisco Giles Pacheco*. Asociación Profesional del Patrimonio Histórico-Arqueológico de Cádiz// Servicio de Publicaciones de la Diputación Provincial de Cádiz, Cádiz, 159–167.

Sanz, M., Daura, J., Cabanes, D., Égüez, N., Carrancho, Á., Badal, E., Souto, P., Rodrigues, F. & Zilhão, J. (2020). Early evidence of fire in south-western Europe: the Acheulean site of Gruta da Aroeira (Torres Novas, Portugal). *Scientific Reports* 10: 12053.

Sanz, M., Daura, J., Costa, A. M. & Araújo, A. C. (2023). The characterization of bearded vulture (Gypaetus barbatus) coprolites in the archaeological record. *Scientific Reports* 13: 57.

Sanz, M., Sala, N., Daura, J., Pantoja-Pérez, A., Santos, E., Zilhão, J. & Arsuaga, J. L. (2018). Taphonomic inferences about Middle Pleistocene hominins: The human cranium of Gruta da Aroeira (Portugal). *American Journal of Physical Anthropology* 167: 615–627.

Snyder, C. W. (2016). Evolution of global temperature over the past two million years. *Nature* 538: 226–228.

Tente, C. & Lourenço, S. (2016). A ocupação da Idade do Ferro da Galeria da Cisterna (sistema cársico da nascente do Almonda, Torres Novas). *Revista Portuguesa de Arqueologia* 19: 143–154.

Trinkaus, E., Bailey, S., Davis, S. J. M. & Zilhão, J. (2011). Magdalenian Human Remains from the Galeria da Cisterna (Almonda karstic system, Torres Novas, Portugal). *O Arqueólogo Português* V-1: 395–413.

Trinkaus, E., Maki, J. & Zilhão, J. (2007). Middle Paleolithic human remains from the Gruta da Oliveira (Torres Novas), Portugal. *American Journal of Physical Anthropology* 134: 263–273.

Trinkaus, E., Marks, A. E., Brugal, J.-P., Bailey, S. E., Rink, W. J. & Richter, D. (2003). Later Middle Pleistocene human remains from the Almonda Karstic system, Torres Novas, Portugal. *Journal of Human Evolution* 45: 219–226.

Varanda, A. (2017). *O Acheulense de Grandes Lascas no Centro Sul de Portugal: Uma comparação entre duas realidades*. M.A., University of Lisbon.

Varanda, A. (2020). Análise comparativa entre o Acheulense de grandes lascas e o Acheulense "tradicional" no centro de Portugal. *Arqueologia & História* 70: 9–24.

Vaz, F. & Tereso, J. (2021). *Lapa dos Coelhos (CLH). Torres Novas. Relatório Técnico de Arqueobotânica*. CIBIO – Centro de Investigação em Biodiversidade e Recursos Genéticos, Porto.

Willmann, J. C., Maki, J., Bayle, P., Trinkaus, E. & Zilhão, J. (2012). Middle Paleolithic human remains from the Gruta da Oliveira (Torres Novas), Portugal. *American Journal of Physical Anthropology* 149: 39–51.

Zilhão, J. (1997). *O Paleolítico Superior da Estremadura portuguesa*, Lisboa, Colibri.

Zilhão, J. (2009). The Early Neolithic artifact assemblage from the Galeria da Cisterna (Almonda karstic system, Torres Novas, Portugal). *De Méditerranée et d'ailleurs. Mélanges offerts à Jean Guilaine*. Archives d'Écologie Préhistorique, Toulouse, 821–836.

Zilhão, J. (2016). Beaker people without beaker pots: the Chalcolithic funerary context from the Galeria da Cisterna (Almonda karst system, Torres Novas, Portugal). *In: el neolític a l'edat del bronze en el Mediterrani occidental. Estudis en homenatge a Bernat Martí Oliver*. Servicio de Investigación Prehistórica, València, 379–386.

Zilhão, J. (2020). The Middle Paleolithic revolution, the origins of art, and the epistemology of paleoanthropology. *In*: P. Días del Río, K. Lillios & I. Sastre (Eds.), *The matter of prehistory: papers in honor of Antonio Gilman Guillén*. Consejo Superior de Investigaciones Científicas, Madrid, 85–104.

Zilhão, J. (2021). New evidence from Galeria da Cisterna (Almonda) and Gruta do Caldeirão on the phasing of Central Portugal's Early Neolithic. *Open Archaeology* 7: 747–764.

Zilhão, J., Angelucci, D., Aubry, T., Badal, E., Brugal, J. P., Carvalho, R., Gameiro, C., Hoffmann, D., Matias, H., Maurício, J., Nabais, M., Pike, A., Póvos, L., Richter, D., Souto, P., Trinkaus, E., Wainer, K. & Weillmann, J. (2013). A Gruta da Oliveira (Torres Novas): uma jazida de referência para o Paleolítico Médio da Península Ibérica. *In*: J. M. Arnaud, A. Martins & C. Neves (Eds.), *Arqueologia em Portugal – 150 Anos*. Associação dos Arqueólogos Portugueses, Lisboa , 259–268.

Zilhão, J. & Angelucci, D. E. (2018). Neandertal Fire. *Proceedings of the European Society for the Study of Human Evolution* 7: 207.

Zilhão, J., Angelucci, D. E., Argant, J., Brugal, J.-P., Carrión, J. S., Carvalho, R., Fuentes, N. & Nabais, M. (2010). Humans and Hyenas in the Middle Paleolithic of Gruta da Oliveira (Almonda karstic system, Torres Novas, Portugal). *In*: E. Baquedano & J. Rosell (Eds.), *Reunión de científicos sobre cubiles de hiena (y otros grandes carnívoros) en los yacimientos arqueológicos de la Península Ibérica*. Museo Arqueológico Regional, Alcalá de Henares, 298–308.

Zilhão, J., Angelucci, D. E., Arnold, L. J., d´Errico, F., Dayet, L., Demuro, M., Deschamps, M., Fewlass, H., Gomes, L., Linscott, B., Matias, H., Pike, A. W. G., Steier, P., Talamo, S. & Wild, E. M. (2021a). Revisiting the Middle and Upper Palaeolithic archaeology of Gruta do Caldeirão (Tomar, Portugal). *PLoS One* 16: e0259089.

Zilhão, J., Angelucci, D. E., Arnold, L. J., Demuro, M., Hoffmann, D. L. & Pike, A. W. G. (2021b). A revised, Last Interglacial chronology for the Middle Palaeolithic sequence of Gruta da Oliveira (Almonda karst system, Torres Novas, Portugal). *Quaternary Science Reviews* 258: 106885.

Zilhão, J., Angelucci, D. E., Igreja, M. A., Arnold, L. J., Badal, E., Callapez, P., Cardoso, J. L., d´Errico, F., Daura, J., Demuro, M., Deschamps, M., Dupont, C., Gabriel, S., Hoffmann, D. L., Legoinha, P., Matias, H., Monge Soares, A. M., Nabais, M., Portela, P., Queffelec, A., Rodrigues, F. & Souto, P. (2020). Last Interglacial Iberian Neandertals as fisher-hunter-gatherers. *Science* 367: eaaz7943.

Zilhão, J. & Carvalho, A. F. (2011). Galeria da Cisterna (rede cárstica da nascente do Almonda). *In*: J. Bernbabeu, M. Rojo & L. Molina (Eds.), *Las primeras producciones cerámicas: el VI milenio cal AC en la Península Ibérica*. València, Universitat de València, 251–254.

Zilhão, J., Maurício, J. & Souto, P. (1991). A Arqueologia da Gruta do Almonda. Resultados das escavações de 1988–89. *Actas das IV Jornadas Arqueológicas (Lisboa, 1990)*. Lisboa: Associação dos Arqueólogos Portugueses.

Zilhão, J., Maurício, J. & Souto, P. (1993). Jazidas arqueológicas do sistema cársico da nascente do Almonda. *Nova Augusta* 7: 35–54.

Zilhão, J. & McKinney, C. (1995). Uranium-Thorium dating of Lower and Middle Paleolithic sites in the Almonda karstic system (Torres Novas, Portugal). *3ª Reunião do Quaternário Ibérico. Actas*. Coimbra: Universidade de Coimbra , 513–516.

Zilhão, J., Monge Soares, A. M. & Pereira Gonçalves, A. (2022). Sperm-whale V-perforated buttons from Galeria da Cisterna (Almonda Karst System, Torres Novas, Portugal). *Trabajos de Prehistoria* 79: 131–140.