



**HAL**  
open science

# Palaeoenvironmental Records and Php Possibilities: Results and Perspectives on an Online Bioarcheological Database

Enora Maguet, Jean-Baptiste Barreau, Chantal Leroyer

► **To cite this version:**

Enora Maguet, Jean-Baptiste Barreau, Chantal Leroyer. Palaeoenvironmental Records and Php Possibilities: Results and Perspectives on an Online Bioarcheological Database. 43rd Annual Conference on Computer Applications and Quantitative Methods in Archaeology, Mar 2015, Siena, Italy. pp.143-156. hal-02459295

**HAL Id: hal-02459295**

**<https://univ-rennes.hal.science/hal-02459295v1>**

Submitted on 31 Jan 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# CAA2015

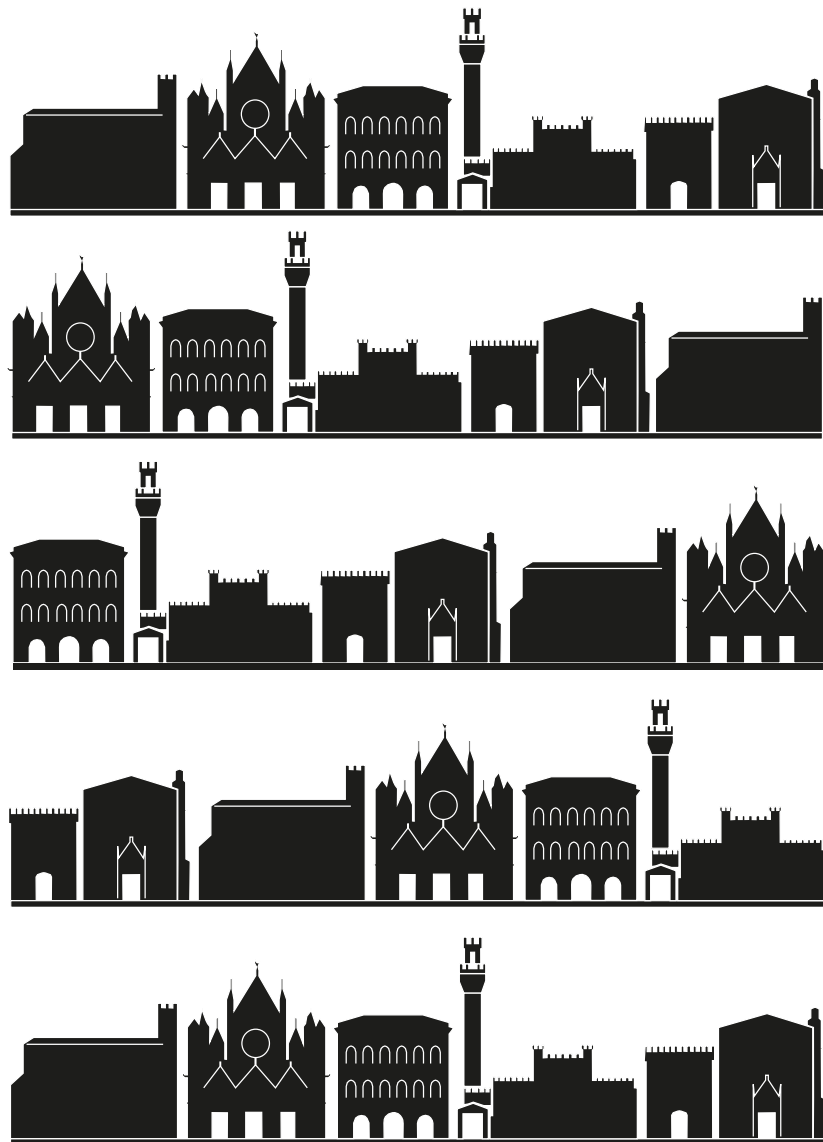
KEEP THE REVOLUTION GOING >>>

Proceedings of the 43rd Annual Conference on Computer Applications and Quantitative Methods In Archaeology

edited by

Stefano Campana, Roberto Scopigno,  
Gabriella Carpentiero and Marianna Cirillo

Volumes 1 and 2



UNIVERSITÀ  
DI SIENA 1240





# **CAA2015**

KEEP THE REVOLUTION GOING >>>

PROCEEDINGS OF THE 43RD ANNUAL CONFERENCE  
ON COMPUTER APPLICATIONS AND QUANTITATIVE  
METHODS IN ARCHAEOLOGY

edited by

**Stefano Campana, Roberto Scopigno,  
Gabriella Carpentiero and Marianna Cirillo**

Volume 1

ARCHAEOPRESS ARCHAEOLOGY

ARCHAEOPRESS PUBLISHING LTD

Gordon House  
276 Banbury Road  
Oxford OX2 7ED

[www.archaeopress.com](http://www.archaeopress.com)

CAA2015

ISBN 978 1 78491 337 3  
ISBN 978 1 78491 338 0 (e-Pdf)

© Archaeopress and the individual authors 2016

CAA2015 is available to download from Archaeopress Open Access site

All rights reserved. No part of this book may be reproduced,  
or transmitted, in any form or by any means, electronic, mechanical, photocopying or otherwise,  
without the prior written permission of the copyright owners.

This book is available direct from Archaeopress or from our website [www.archaeopress.com](http://www.archaeopress.com)

# Table of Contents

<b>Introduction</b> .....	ix
Stefano Campana, Roberto Scopigno	
<b>Introductory Speech</b> .....	x
Professor Gabriella Piccinni	
<b>Foreword</b> .....	xi
Professor Emanuele Papi	
<b>Acknowledgements</b> .....	xii
<b>CHAPTER 1</b>	
<b>TEACHING AND COMMUNICATING DIGITAL ARCHAEOLOGY</b> .....	1
<b>From the Excavation to the Scale Model: a Digital Approach</b> .....	3
Hervé Tronchère, Emma Bouvard, Stéphane Mor, Aude Fernagu, Jules Ramona	
<b>Teaching Digital Archaeology Digitally</b> .....	11
Ronald Visser, Wilko van Zijverden, Pim Alders	
<b>3D Archaeology Learning at the Paris 1 Pantheon Sorbonne University</b> .....	17
François Djindjian	
<b>How to Teach GIS to Archaeologists</b> .....	21
Krzysztof Misiewicz, Wiesław Małkowski, Miron Bogacki, Urszula Zawadzka-Pawlewska, Julia M. Chyla	
<b>Utilisation of a Game Engine for Archaeological Visualisation</b> .....	27
Teija Oikarinen	
<b>The Interplay of Digital and Traditional Craft: re-creating an Authentic Pictish Drinking Horn Fitting</b> .....	35
Dr Mhairi Maxwell, Jennifer Gray, Dr Martin Goldberg	
<b>Computer Applications for Multisensory Communication on Cultural Heritage</b> .....	41
Lucia Sarti, Stefania Poesini, Vincenzo De Troia, Paolo Machetti	
<b>Interactive Communication and Cultural Heritage</b> .....	51
Tommaso Empler, Mattia Fabrizi	
<b>Palaeontology 2.0 - Public Awareness of Palaeontological Sites Through New Technologies</b> .....	59
Tommaso Empler, Fabio Quici, Luca Bellucci	
<b><i>Lucus Feroniae and Tiber Valley Virtual Museum: from Documentation and 3d Reconstruction, Up to a Novel Approach in Storytelling, Combining Virtual Reality, Theatrical and Cinematographic Rules, Gesture-based Interaction and Augmented Perception of the Archaeological Context</i></b> .....	67
Eva Pietroni, Daniele Ferdani, Augusto Palombini, Massimiliano Forlani, Claudio Rufa	
<b>CHAPTER 2</b>	
<b>MODELLING THE ARCHAEOLOGICAL PROCESS</b> .....	79
<b>Principal Component Analysis of Archaeological Data</b> .....	81
Juhana Kammonen, Tarja Sundell	
<b>IT-assisted Exploration of Excavation Reports. Using Natural Language Processing in the Archaeological Research Process</b> ...	87
Christian Chiarcos, Matthias Lang, Philip Verhagen	
<b>A 3d Visual and Geometrical Approach to Epigraphic Studies. The Soli (Cyprus) Inscription as a Case Study</b> .....	95
Valentina Vassallo, Elena Christophorou, Sorin Hermon, Lola Vico, Giancarlo Iannone	
<b>Modelling the Archaeological Record: a Look from the Levant. Past and Future Approaches</b> .....	103
Sveta Matskevich, Ilan Sharon	
<b>3D Reconstitution of the Loyola Sugar Plantation and Virtual Reality Applications</b> .....	117
Barreau J.B., Petit Q., Bernard Y., Auger R., Le Roux Y., Gagne R., Gouranton V.	

<b>Integrated Survey Techniques for the Study of an Archaeological Site of Medieval Morocco</b> .....	125
Lorenzo Teppati Losè	
<b>CHAPTER 3</b>	
<b>INTERDISCIPLINARY METHODS OF DATA RECORDING</b> .....	131
<b>3-Dimensional Archaeological Excavation of Burials Utilizing Computed Tomography Imaging</b> .....	133
Tiina Väre, Sanna Lipkin, Jaakko Niinimäki, Sirpa Niinimäki, Titta Kallio-Seppä, Juho-Antti Junno, Milton Núñez, Markku Niskanen, Matti Heino, Annemari Tranberg, Saara Tuovinen, Rosa Vilkama, Timo Ylimaunu	
<b>Palaeoenvironmental Records and Php Possibilities: Results and Perspectives on an Online Bioarcheological Database</b> .....	143
Enora Maguet, Jean-Baptiste Barreau, Chantal Leroyer	
<b>Integrated Methodologies for the Reconstruction of the Ancient City of Lixus (Morocco)</b> .....	157
Cynthia Mascione, Rossella Pansini, Luca Passalacqua	
<b>A Dig in the Archive. The Mertens Archive of Herdonia Excavations: from Digitisation to Communication</b> .....	167
Giuliano De Felice, Andrea Fratta	
<b>Archaeological and Physicochemical Approaches to the Territory: On-site Analysis and Multidisciplinary Databases for the Reconstruction of Historical Landscapes</b> .....	177
Luisa Dallai, Alessandro Donati, Vanessa Volpi, Andrea Bardi	
<b>Interdisciplinary Methods of Data Recording, Management and Preservation</b> .....	187
Marta Lorenzon, Cindy Nelson-Viljoen	
<b>Driving Engagement in Heritage Sites Using Personal Mobile Technology</b> .....	191
Thom Corah, Douglas Cawthorne	
<b>A Conceptual and Visual Proposal to Decouple Material and Interpretive Information About Stratigraphic Data</b> .....	201
Patricia Martin-Rodilla, Cesar Gonzalez-Perez, Patricia Mañana-Borrazas	
<b>Recording, Preserving and Interpreting a Medieval Archaeological Site by Integrating Different 3d Technologies</b> .....	213
Daniele Ferdani, Giovanna Bianchi	
<b>A 3D Digital Approach to Study, Analyse and (Re)Interpret Cultural Heritage: the Case Study of Ayia Irini (Cyprus and Sweden)</b> .....	227
Valentina Vassallo	
<b>CHAPTER 4</b>	
<b>LINKING DATA</b> .....	233
<b>Beyond the Space: The LoCloud Historical Place Names Micro-Service</b> .....	235
Rimvydas Laužikas, Ingrida Vosyliūtė, Justinas Jaronis	
<b>Using CIDOC CRM for Dynamically Querying ArSol, a Relational Database, from the Semantic Web</b> .....	241
Olivier Marlet, Stéphane Curet, Xavier Rodier, Béatrice Bouchou-Markhoff	
<b>Connecting Cultural Heritage Data: The Syrian Heritage Project in the IT Infrastructure of the German Archaeological Institute</b> .....	251
Sebastian Cuy, Philipp Gerth, Reinhard Förtsch	
<b>The Labelling System: A Bottom-up Approach for Enriched Vocabularies in the Humanities</b> .....	259
Florian Thiery, Thomas Engel	
<b>Providing 3D Content to Europeana</b> .....	269
Andrea D'Andrea	
<b>How To Move from Relational to 5 Star Linked Open Data – A Numismatic Example</b> .....	275
Karsten Tolle, David Wigg-Wolf	
<b>Homogenization of the Archaeological Cartographic Data on a National Scale in Italy</b> .....	283
Giovanni Azzena, Roberto Busonera, Federico Nurra, Enrico Petruzzi	
<b>The GIS for the 'Forma Italiae' Project. From the GIS of the Ager Venusinus Project to the GIS of the Ager Lucerinus Project: Evolution of the System</b> .....	293
Maria Luisa Marchi, Giovanni Forte	

<b>GIS, An Answer to the Challenge of Preventive Archaeology? The Attempts of the French National Institute for Preventive Archaeology (Inrap)</b> .....	303
Anne Moreau	
<b>Dynamic Distributions in Macro and Micro Perspective</b> .....	309
Espen Uleberg, Mieko Matsumoto	
<b>CHAPTER 5</b>	
<b>NEW TRENDS IN 3D ARCHAEOLOGY</b> .....	
319	
<b>Hand-free Interaction in the Virtual Simulation of the Agora of Segesta</b> .....	321
Riccardo Olivito, Emanuele Taccola, Niccolò Albertini	
<b>Master-Hand Attributions of Classical Greek Sculptors by 3D-Analysis at Olympia - Some Preliminary Remarks</b> .....	329
A. Patay-Horváth	
<b>Using 3D Models to Analyse Stratigraphic and Sedimentological Contexts in Archaeo-Palaeo-Anthropological Pleistocene Sites (Gran Dolina Site, Sierra De Atapuerca)</b> .....	337
I. Campaña, A. Benito-Calvo, A. Pérez-González, A. I. Ortega, J.M. Bermúdez de Castro, E. Carbonell	
<b>Establishing Parameter Values for the Stone Erosion Process</b> .....	347
Igor Barros Barbosa, Kidane Fanta Gebremariam, Panagiotis Perakis, Christian Schellewald, Theoharis Theoharis	
<b>The New Trend of 3D Archaeology is ... Going 2D!</b> .....	363
Giuliano De Felice	
<b>Documentation and Analysis Workflow for the On-going Archaeological Excavation with Image-Based 3d Modelling Technique: the Case-study of the Medieval Site of Monteleo, Italy</b> .....	369
Giulio Poggi	
<b>3D Technology Applied to Quantification Studies of Pottery: Eve 2.0</b> .....	377
Miguel Busto-Zapico, Miguel Carrero-Pazos	
<b>3D Recording of Archaeological Excavation: the Case of Study of Santa Marta, Tuscany, Italy</b> .....	383
Matteo Sordini, Francesco Brogi, Stefano Campana	
<b>Visual Space, Defence, Control and Communication: Towers and Fortresses System of the Tuscan Coastal Belt and Islands</b> 393	
Michele De Silva	
<b>CHAPTER 6</b>	
<b>INTEGRATING 3D DATA</b> .....	
397	
<b>Photomodelling And Point Cloud Processing. Application in the Survey of the Roman Theatre of <i>Uthina</i> (Tunisia) Architectural Elements</b> .....	399
Meriem Zammel	
<b>Deconstructing Archaeological Palimpsests: Applicability of GIS Algorithms for the Automated Generation of Cross Sections</b> .....	407
Miquel Roy Sunyer	
<b>Pompeii, the Domus of Stallius Eros: a Comparison Between Terrestrial and Aerial Low-cost Surveys</b> .....	415
Angela Bosco, Marco Barbarino, Rosario Valentini, Andrea D'Andrea	
<b>Pottery Goes Digital. 3D Laser Scanning Technology and the Study of Archaeological Ceramics</b> .....	421
Martina Revello Lami, Loes Opgenhaffen, Ivan Kisjes	
<b>ARIADNE Visual Media Service: Easy Web Publishing of Advanced Visual Media</b> .....	433
Federico Ponchio, Marco Potenziani, Matteo Dellepiane, Marco Callieri, Roberto Scopigno	
<b>Mapping Archaeological Databases to CIDOC CRM</b> .....	443
Martin Doerr, Maria Theodoridou, Edeltraud Aspöck, Anja Masur	
<b>Scientific Datasets in Archaeological Research</b> .....	453
Nikolaos A. Kazakis, Nestor C. Tsirliganis	



## CHAPTER 7

<b>SPATIAL ANALYSIS: THEORIES, QUESTIONS AND METHODS</b> .....	461
<b>Fuzzy Classification of Gallinazo and Mochica Ceramics in the North Coast, Peru Using the Jaccard Coefficient</b> .....	463
Kayeleigh Sharp	
<b>Dynamics of the Settlement Pattern in the Aksum Area (800-400 Bc). an ABM Preliminary Approach</b> .....	473
Martina Graniglia, Gilda Ferrandino, Antonella Palomba, Luisa Sernicola, Giuseppe Zollo, Andrea D’Andrea, Rodolfo Fattovich, Andrea Manzo	
<b>An Application of Agent-Based Modelling and GIS in Minoan Crete</b> .....	479
Angelos Chliaoutakis, Georgios Chalkiadakis, Apostolos Sarris	
<b>Evaluating the Crisis: Population and Land Productivity in Late Medieval Salento, Italy</b> .....	489
Giuseppe Muci	
<b>When GIS Goes to the Countryside: Detecting and Interpreting Roman Orchards from the ‘Grand Palais’ (Drôme, France)</b> .	499
Christophe Landry, Bertrand Moulin	
<b>GIS Applications and Spatial Analysis for the Survey of the Prehistoric Northern Apennine Context: the Case Study of the Mugello in Tuscany</b> .....	517
Andrea Capecchi, Michele De Silva, Fabio Martini, Lucia Sarti	
<b>The Statistics of Time-to-Event. Integrating the Bayesian Analysis of Radiocarbon Data and Event History Analysis Methods</b> .....	533
Juan Antonio Barceló, Giacomo Capuzzo, Berta Morell, Katia Francesca Achino, Agueda Lozano	
<b>Hypothesis Testing and Validation in Archaeological Networks</b> .....	543
Peter Bikoulis	
<b>Traveling Across Archaeological Landscapes: the Contribution of Hierarchical Communication Networks</b> .....	555
Sylviane Déderix	
<b>Dispersal Versus Optimal Path Calculation</b> .....	567
Irmela Herzog	
<b>Visibility Analysis and the Definition of the Iltergetian Territory: the Case of Montderes</b> .....	579
Núria Otero Herraiz	
<b>CHAPTER 8</b>	
<b>SPATIAL ANALYSIS: PREDICTIVITY AND POSTDICTIVITY IN ARCHAEOLOGY</b> .....	591
<b>Predictivity – Postdictivity: a Theoretical Framework</b> .....	593
Antonia Arnoldus-Huyzendveld, Carlo Citter, Giovanna Pizziolo	
<b>Predicting and Postdicting a Roman Road in the Pre-pyrenees Area of Lleida (Spain)</b> .....	599
Antonio Porcheddu	
<b>Predict and Confirm: Bayesian Survey and Excavation at Three Candidate Sites for Late Neolithic Occupation in Wadi Quseiba, Jordan</b> .....	605
Philip M.N. Hitchings, Peter Bikoulis, Steven Edwards, Edward B. Banning	
<b>Predicting Survey Coverage through Calibration: Sweep Widths and Survey in Cyprus and Jordan</b> .....	613
Sarah T. Stewart, Edward B. Banning, Steven Edwards, Philip M.N. Hitchings, Peter Bikoulis	
<b>Estimating The ‘Memory of Landscape’ to Predict Changes in Archaeological Settlement Patterns</b> .....	623
Philip Verhagen, Laure Nuninger, Frédérique Bertoncello, Angelo Castrorao Barba	
<b>On Their Way Home ... A Network Analysis of Medieval Caravanserais Distribution in the Syrian Region, According to an 1D Approach</b> .....	637
Augusto Palombini, Cinzia Tavernari	
<b>Modelling Regional Landscape Through the Predictive and Postdictive Exploration of Settlement Choices: a Theoretical Framework</b> .....	647
Emeri Farinetti	
<b>Site Location Modelling and Prediction on Early Byzantine Crete: Methods Employed, Challenges Encountered</b> .....	659
Kayt Armstrong, Christina Tsigonaki, Apostolos Sarris, Nadia Coutsinas	

<b>Potential Paths and the Historical Road Network between Italy and Egypt: from the Predictive to the Postdictive Approach.....</b>	669
Andrea Patacchini, Giulia Nicatore	
<b>CHAPTER 9</b>	
<b>SPATIAL ANALYSIS: OCCUPATION FLOORS AND PALAEOURFACES IN THE DIGITAL ERA .....</b>	683
<b>Ritual use of Romito Cave During the Late Upper Palaeolithic: an Integrated Approach for Spatial Reconstruction .....</b>	685
Michele De Silva, Giovanna Pizziolo, Domenico Lo Vetro, Vincenzo De Troia, Paolo Machetti, Enrico F. Ortisi, Fabio Martini	
<b>Visualizing Occupation Features in Homogenous Sediments. Examples from the Late Middle Palaeolithic of Grotte De La Verpillière II, Burgundy, France .....</b>	699
Jens Axel Frick	
<b>A New Palaeolithic Burial From Grotta Del Romito (Calabria, Italy). A Digital Restitution .....</b>	715
Francesco Enrico Ortisi, Domenico Lo Vetro, Giovanna Pizziolo, Michele De Silva, Claudia Striuli, Pier Francesco Fabbri, Fabio Martini	
<b>Predicting the Accumulative Consequences of Abandonment Processes. Intra-site Analysis of Lakeside Settlements .....</b>	723
Katia Francesca Achino, Juan Antonio Barceló, Micaela Angle	
<b>Reconstructing the Boom of Prehistoric Hunter-Gatherer Population Size in Finland by Agent and Equation-Based Modelling .....</b>	733
Tarja Sundell, Martin Heger, Juhana Kammonen	
<b>Archaeology, Geomorphology and Palaeosurfaces Studies: a Multidisciplinary Approach for Understanding the Ancient Laos Territory.....</b>	739
Vincenzo Amato, Cristiano Benedetto De Vita, Francesca Filocamo, Alfonso Santoriello, Francesco Uliano Scelza	
<b>Intrasite Analysis in the Florentine Plain: from Data Integration to Palaeosurfaces Interpretation .....</b>	749
Giovanna Pizziolo, Nicoletta Volante, Lucia Sarti	
<b>Living in a Palaeoriverbed: Intra-site Analysis of Two Prehistoric Sites in the Florentine Alluvial Plain .....</b>	761
Rosalba Aquino, Matteo Faraoni, Laura Morabito, Giovanna Pizziolo, Lucia Sarti	
<b>Exploring Scenarios for the First Farming Expansion in the Balkans Via an Agent-based Model .....</b>	773
Andrea Zanotti, Richard Moussa, Jérôme Dubouloz, Jean-Pierre Bocquet-Appel	
<b>CHAPTER 10</b>	
<b>SPATIAL ANALYSIS: DATA, PATTERNS AND PROCESS INTERPRETATION .....</b>	781
<b>Strontium Isotope Analysis and Human Mobility from Late Neolithic to Early Bronze Age in the Central Plain of China .....</b>	783
Chunyan Zhao	
<b>The Iron Age in Serakhs Oasis (Turkmenistan). The Preliminary Results of the Application of Geographic Information System in the Study of the Settlement Pattern of the Earliest Confirmed Occupation of the Oasis .....</b>	791
Nazarj Bulawka, Barbara Kaim	
<b>Multi-Scale Approach for the Reconstruction of a Past Urban Environment. From Remote Sensing to Space Syntax: the Case of <i>Dionysias</i> (Fayum, Egypt) .....</b>	803
Gabriella Carpentiero, Carlo Tessaro	
<b>Enhancing GIS Urban Data with the 3rd Dimension: A Procedural Modelling Approach.....</b>	815
Chiara Piccoli	
<b>Structural Integrity Modelling of an Early Bronze Age Corridor House in Helike of Achaea, NW Peloponnese, Greece .....</b>	825
Mariza Kormann, Stella Katsarou, Dora Katsonopoulou, Gary Lock	
<b>Discovering Prehistoric Ritual Norms. A Machine Learning Approach. ....</b>	837
Stéphanie Duboseq, Joan Anton Barceló Álvarez, Katia Francesca Achino, Berta Morell Rovira, Florence Alliése, Juan Francisco Gibaja Bao	
<b>Application of the ‘Bag of Words’ Model (bow) for Analysing Archaeological Potsherds.....</b>	847
Diego Jiménez-Badillo, Edgar Roman-Rangel	

<b>Autonomy in Marine Archaeology</b> .....	857
Øyvind Ødegård, Stein M. Nornes, Martin Ludvigsen, Thijs J. Maarleveld, Asgeir J. Sørensen	
<b>Identifying Patterns on Prehistoric Wall Paintings: a New Curve Fitting Approach</b> .....	867
Michail Panagopoulos, Dimitris Arabadjis, Panayiotis Rousopoulos, Michalis Exarhos, Constantin Papaodysseus	
<b>Pottery Studies of the 4th-Century Necropolis at Bârlad-Valea Seacă, Romania</b> .....	875
Vlad-Andrei Lăzărescu, Vincent Mom	
<b>A Bridge to Digital Humanities: Geometric Methods and Machine Learning for Analysing Ancient Script in 3D</b> .....	889
Hubert Mara, Bartosz Bogacz	
<b>CHAPTER 11</b>	
<b>REMOTE SENSING: COMPUTATIONAL IMAGING ADVANCES AND SENSOR DATA INTEGRATION</b> .....	
899	
<b>The Possibilities of the Aerial Lidar for the Detection of Galician Megalithic Mounds (NW of the Iberian Peninsula). The Case of Monte De Santa Mariña, Lugo</b> .....	901
Miguel Carrero-Pazos, Benito Vilas-Estévez	
<b>Reflectance Transformation Imaging Beyond the Visible: Ultraviolet Reflected and Ultraviolet Induced Visible Fluorescence</b> .....	909
E. Kotoula	
<b>Endangered Archaeology in the Middle East and North Africa: Introducing the EAMENA Project</b> .....	919
Robert Bewley, Andrew Wilson, David Kennedy, David Mattingly, Rebecca Banks, Michael Bishop, Jennie Bradbury, Emma Cunliffe, Michael Fradley, Richard Jennings, Robyn Mason, Louise Rayne, Martin Sterry, Nichole Sheldrick, Andrea Zerbini	
<b>Enhancing Multi-Image Photogrammetric 3d Reconstruction Performance on Low-Feature Surfaces</b> .....	933
George Ioannakis, Anestis Koutsoudis, Blaž Vidmar, Fotis Arnaoutoglou, Christodoulos Chamzas	
<b>Combination of RTI and Decorrelation — an Approach to the Examination of Badly Preserved Rock Inscriptions and Rock Art at Gebelein (Egypt)</b> .....	939
Piotr Witkowski, Julia M. Chyla, Wojciech Ejsmond	
<b>Geophysical-Archaeological Experiments in Controlled Conditions at the Hydrogeosite Laboratory (CNR-IMAA)</b> .....	945
Felice Perciante, Luigi Capozzoli L., Antonella Caputi, Gregory De Martino, Valeria Giampaolo, Raffaele Luongo, Enzo Rizzo	
<b>Colour and Space in Cultural Heritage in 6Ds: the Interdisciplinary Connections</b> .....	953
Anna Bentkowska-Kafel, Julio M. del Hoyo Melendez, Lindsay W. MacDonald, Aurore Mathys, Vera Moitinho de Almeida	
<b>Integrating Low Altitude with Satellite and Airborne Aerial Images: Photogrammetric Documentation of Early Byzantine Settlements in Crete</b> .....	963
Gianluca Cantoro, Christina Tsigonaki, Kayt Armstrong, Apostolos Sarris	
<b>Creating 3D Replicas of Medium- to Large-Scale Monuments for Web-Based Dissemination Within the Framework of the 3D-Icons Project</b> .....	971
Anestis Koutsoudis, Fotios Arnaoutoglou, Vasilios Liakopoulos, Athanasios Tsaouselis, George Ioannakis, Christodoulos Chamzas	
<b>The Lidoriki Project: Low Altitude, Aerial Photography, GIS, and Traditional Survey in Rural Greece</b> .....	979
Todd Brenningmeyer, Kostis Kourelis, Miltiadis Katsaros	
<b>A Fully Integrated UAV System for Semi-automated Archaeological Prospection</b> .....	989
Matthias Lang, Thorsten Behrens, Karsten Schmidt, Dieta Svoboda, Conrad Schmidt	
<b>Stereo Visualization of Historical Aerial Photos as a Valuable Tool for Archaeological Research</b> .....	997
Anders Hast, Andrea Marchetti	
<b>CHAPTER 12</b>	
<b>OPEN SOURCE AND OPEN DATA</b> .....	
1003	
<b>Strati5 - Open Mobile Software for Harris Matrix</b> .....	1005
Jerzy Sikora, Jacek Sroka, Jerzy Tyszkiewicz	
<b>Archaeology as Community Enterprise</b> .....	1015
Néhémie Strupler	

<b>Digital Resources for Archaeology. The Contribution of the On-Line Projects by Isma-Cnr</b> .....	1019
Alessandra Caravale, Alessandra Piergrossi	
<b>A Swabian in the Orient. In the Footsteps of Julius Euting</b> .....	1027
Matthias Lang, Manuel Abbt, Gerlinde Bigga, Jason T. Herrmann, Virginia Hermann, Kevin Körner, Fabian Schwabe, Dieta Svoboda	
<b>GQBWiki Goes Open</b> .....	1033
Stefano Costa, Alessandro Carabia	
<b>Archaeological Contents: from Open Access to Open Data</b> .....	1037
Aurélie Monteil, Viviane Boulétreau	
<b>CHAPTER 13</b>	
<b>COMPUTERS AND ROCK ART STUDIES</b> .....	1047
<b>Archaeoacoustics of Rock Art: Quantitative Approaches to the Acoustics and Soundscape of Rock Art</b> .....	1049
Margarita Díaz-Andreu, Tommaso Mattioli	
<b>Photometric Stereo 3D Visualizations of Rock-Art Panels, Bas-Reliefs, and Graffiti</b> .....	1059
Massimo Vanzi, Paolo Emilio Bagnoli, Carla Mannu, Giuseppe Rodriguez	
<b>SIVT – Processing, Viewing, and Analysis of 3D Scans of the Porthole Slab and Slab B2 of Züschen I</b> .....	1067
Stefanie Wefers, Tobias Reich, Burkhard Tietz, Frank Boochs	
<b>Digital Practices for the Study of the Great Rock in the Naquane National Park, Valcamonica, Italy: from Graphic Rendering to Figure Cataloguing</b> .....	1081
Andrea Arcà	
<b>Real-time 3D Modelling of the Cultural Heritage: the Forum of Nerva in Rome</b> .....	1093
Tommaso Empler, Barbara Forte, Emanuele Fortunati	
<b>Mediated Representations After Laser Scanning. The Monastery of Aynalı and the Architectural Role of Red Pictograms.</b>	1105
Carlo Inglese, Marco Carpiceci, Fabio Colonnese	

# Palaeoenvironmental Records and Php Possibilities: Results and Perspectives on an Online Bioarcheological Database

Enora Maguet

enora.maguet@gmail.com

Jean-Baptiste Barreau

jean-baptiste.barreau@univ-rennes1.fr

Chantal Leroyer

chantal.leroyer@univ-rennes1.fr

UMR 6566 CREAAH, Université de Rennes 1, France

*Abstract: ABCData project is an online bioarchaeological database, that essentially gathers palynological and anthracological data. This relational database was built using a framework (FuelPHP), and the different interfaces and applications were all developed through computer programming, using several languages and open access libraries. In particular, we developed a palynological query interface associated to a SVG graphics generation tool. We tested ABCData's functioning through the integration and the analysis of numerous palynological cores that had already been studied with a different method. This study revealed a great accordance between the two methods, and highlighted some bias and the necessity of permanently watching over of the statistic distribution of the samples.*

*Keywords: Database, Programming, Palaeoenvironment, Interdisciplinary, PHP*

## Introduction

Over the last few years, palaeoenvironmental matters have been more systematically integrated to archaeological questions. The difficulties that are inherent to these multiproxy studies lead us to attach a prior attention to the IT management of a huge data corpus, which gather several disciplines and set numerous problems of storing, safeguarding, using and standardizing this complex information.

In the national and European context, there are many projects (GDRE Bioarch, ANR Bioarchéodat) and databases (Arbodot, I2AF, European Pollen Database) whose main objective is to enable the data collection, comparison and overview through a normalized frame of reference and appropriate computer-based tools. All these bases, if meant to coexist and enrich each other, must allow collaboration and must be fully compatible or interoperable. Such aspect is perhaps the biggest difficulty and one of the main concerns databases creators and administrators have to deal with.

Nevertheless, these projects mostly concern anthracology, carpology and archaeozoology. As a consequence, palynological data is often treated separately since its applications are out of the field of archaeology. It is also challenging to handle these data because of the difficulties linked to the chronological assignment of samples, the amount of data required to interpret the results, the differences between the sequences in terms of preservation and level of taxinomical identification, as well as the conditions which affect the archaeological site (Reille 1990).

Our project ABCData (Archaeology, Biodiversity, Chronology Data) focused on creating a tool for the input, the visualisation

and the use of paleobotanical data which works in consonance with the specificities of this discipline. In order to overcome the difficulty of using a local software program, we transferred the data to a server, and we built a website (<http://archeosciences-abcdata.osuris.org>) which handles all the functionalities of the database. The start of the programming work used an open framework (FuelPHP 5.3) to develop the interface basic tools. This database was then fully programmed with different languages (php, javascript, html, css) and different libraries in open access gives. As a result, it is a very flexible tool which fits well the needs of palaeoenvironmental disciplines, helping us to explore new possibilities in terms of analysis and graphic visualisation of results. Thus, one of the major aspects of this project is the setting of a query interface (for the time being, the interface deals only with palynological input) which allows us to conduct both synthetic and parametric approaches of the integrated data. A graphic displaying tool and a library (PHPEXcel) which enables importing and exporting results under a spreadsheet are also related to the query interface.

The final phase was devoted to a series of analyses of the palynological content of 43 sedimentary cores from the Paris Basin, in order to compare ABCData performances to the synthetic history of the basin vegetation set on the empirical merging of the same data, since the late Epipaleolithic times (Leroyer 1997).

## 1 Database creation

ABCData's functioning relies on the existence of two complementary interfaces: an administrator interface handled by PhpPgadmin, and a user interface, resulting from our programming work. The putting on line of the database has therefore taken place in several steps. First we designed the

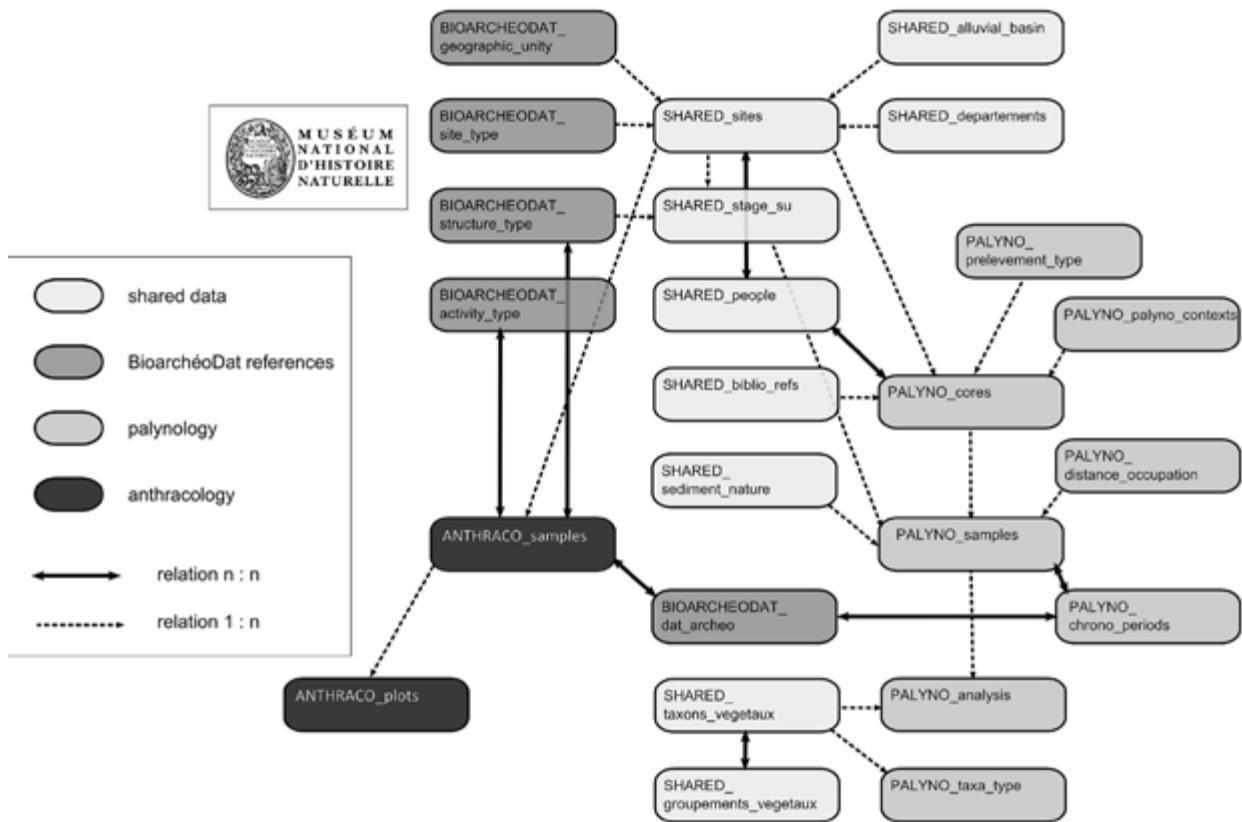


FIG. 1. ABCDATA'S RELATIONAL ARCHITECTURE.

structures of the tables and the nature of the links between them, then we had to create these tables in PhpPgadmin, to translate this architecture within the source files, and finally to program all the ABCData's specific functionalities.

### 1.1 Data architecture

Fundamentally the data dealt through ABCData aim to quantify the taxa occurrences (only botanical taxa for the moment) in the analysed samples, while preserving all information liable to enlighten this analyse such as dating, evaluation of the preservation quality, analysis methods or archaeological context.

It is particularly essential to use common and normalized vocabulary in order to carry out analyses on different sequences or different materials. This is one of the advantages of using permanent tables (Kreuz and Shafer 2002), which help to standardize input and exclude redundancies. All the data shared by several elements must appear in one same table in order to avoid as far as possible the redundant elements. ABCData is therefore composed by a large number of tables (Fig. 1) belonging to four categories identified with a prefix: the specific data about anthracology, the specific data about palynology, the data belonging to the different disciplines and the permanent data issuing from Bioarcheodat project frame references. Each table includes an identifying field on which weighs a uniqueness obligation and which is automatically filled by the sequence associated to the table. The n-n (or many to many) relation type are expressed within specific tables. It

constitutes an adapted answer to situations where a record can be associated to different values of the same attribute, and these attribute values associated to several records.

The organisation of palynological data, widely inherited from the already developed SGBDR (Maguet 2013), has nevertheless gone through many modifications, for it was absolutely necessary to take into account the interoperability with other SGBD and the compatibility with anthracological data. The table corresponding to botanical taxa was conceived in order to deal with problems caused by the differences in the resolution level of taxa determination, both between palynology and anthracology, and between several sequences of pollen or charcoal. Indeed, many parameters may influence upon the degree of precision of these determinations, such as material preservation, microscope performances or the analyst's own sensibility (Maguet 2014). It therefore contains a field 'name' which corresponds to the most common degree of determination, and a field 'precision' which allows the user to indicate additional information when a more precise degree of determination is possible.

### 1.2 Data integration into PhpPgadmin

The administrator interface PhpPgadmin, which works with PostgreSQL, allows us to create, to define, to update and delete the different tables and their fields. The link between these tables relies on the existence of primary keys ('id') that are absolutely unique and automatically incremented using numerical sequences. The use of a relational model had already

Spreadsheet formula

E2    fx Σ =    = "INSERT INTO commun\_taxons\_vegetaux VALUES ('"&A2&"', "&B2'", '&C2&"', "&D2&"');"

	A	B	C	D	E	F	G	H	I	J	K
1	id	nom_taxon	id_type_taxon	precision							
2	1	ABIES	3	NULL	INSERT INTO commun_taxons_vegetaux VALUES (1, 'ABIES', 3, NULL);						
3	2	ACER	3	NULL	INSERT INTO commun_taxons_vegetaux VALUES (2, 'ACER', 3, NULL);						
4	3	RANONCULACEAE	2	ADONIS	INSERT INTO commun_taxons_vegetaux VALUES (3, 'RANONCULACEAE', 2, 'ADONIS');						
5											

SQL command

FIG. 2. SPREADSHEET FORMULA AND SQL COMMANDS.

phpPgadmin window

Colonne	Type	NOT NULL	Défaut	Contraintes	Actions	Commentaire
id	integer	NOT NULL	nextval('taxons_id_seq'::regclass)		Parcourir   Modifier   Supprimer	
nom	character(32)				Parcourir   Modifier   Supprimer	

MS-DOS shell panel

```
C:\Users\jb\Desktop\fuelphp-1.5.2>php oil generate scaffold/crud anthracotaxons
non:character(32)
Creating migration: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\migration
s/002_create_anthracotaxons.php
Creating model: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\classes\node1
/anthracotaxon.php
Creating controller: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\classes/
controller/anthracotaxons.php
Creating view: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\views/anthraco
taxons/index.php
Creating view: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\views/anthraco
taxons/view.php
Creating view: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\views/anthraco
taxons/create.php
Creating view: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\views/anthraco
taxons/edit.php
Creating view: C:\Users\jb\Desktop\fuelphp-1.5.2\fuel\app\views/anthraco
taxons/_form.php
```

FIG. 3. MS-DOS FILES GENERATING PROCESS.

been recommended and the functioning widely described by Tomlinson (1993), when he created an archaeobotanical database on British and Irish datasets. He particularly insisted on the fact that this relational model is based on the creation of independent tables in which every line must be different and identified by a primary key that should preferably be a numeric element.

In phpPgadmin, you can input your data directly, but generally it is more convenient to use SQL commands which correspond to the updating commands (INSERT, UPDATE, and DELETE) (Fig. 2). Using these commands, the integration of data from spreadsheets goes very fast.

### 1.3 Creation of the source files

The creation of the CRUD (Create, Read, Update, Delete) source files was realized thanks to a web open-source

framework called FuelPHP. This framework follows the HMVC (Hierarchical Model View Controller) architecture. This technology ensures the possibility to generate automatically the source files when their architecture is widely repeated, as well as writing the code which corresponds to the major functions from the CRUD. This first step is realized through the MS DOS Shell (Fig. 3), and allows us to have, for each table of phpPgadmin, different source files: a controller, a model, and a set of five different views (index, view, \_form, create, edit). In the controller, there are different functions that are associated to each view, and who define and compute every variable that is called in the view files.

Mostly, these variables rely on the data from the phpPgadmin interface, and it is the model that ensures the link between these data and the controller (Fig. 4). The variables often correspond to associative tables, called 'arrays', which means that they are composed by the association of a key to a set of different values

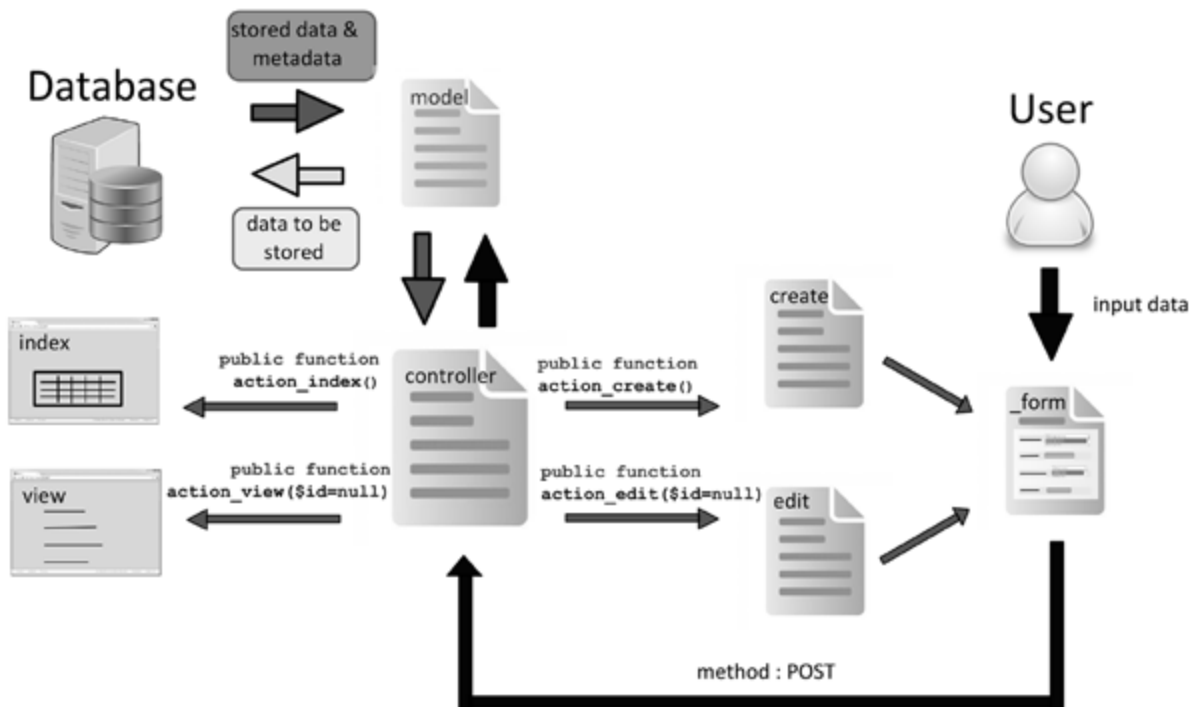


FIG. 4. RELATIONS BETWEEN THE DIFFERENT SOURCE FILES, THE BASE AND THE USER.

or attributes. Again, this attribute can also be an array, which is nested within the first one. This interlocking of data constitutes an essential point concerning php data management. To access the different levels and values, you can use the square bracket based syntax when the loop system allows you to browse every line of a given array (Fig. 5).

All these source files must be then transferred on the server using a FTP client such as FileZilla. After that, they can be updated through a code source editor (such as Notepad ++), connected to the FTP server.

**2 Development of tools**

We were able to work on an interface which met our needs in terms of display, input, import/export, queries and even security, from the files generated by the FuelPHP framework and thanks to different programming languages. Generally, the structure of the files proposed by the framework imitates the structure of the base, its tables and fields. The interface we seek to construct, however, is different from this architecture so as to answer as efficiently as possible to the users' demands.

Furthermore, we analysed the functionalities of Gpalwin, a program that was adapted to the palynologists' needs (Goeury 1997), and it led us to add more fields. These fields contain information mainly about calculations on the characteristics of samples and profiles in terms of diversity of the pollen content.

**2.1 Data import and export: Forms**

The use of forms ensures the direct input of the data into the base. Different data types correspond to different field types: Text data will be shown in drop-down lists; numerical data

must be provided in numbers whose format is defined in the structure of the table. Another possibility is creating checkboxes for Boolean data. In the forms, the fields correspond mainly to html programming, where data is retrieved from php variables, essentially for displaying drop-down lists (Fig. 6).

[Fig. 6: Relations between different source files while creating form fields]

All data provided by the user will be inserted into the controller through the \$\_POST variable, and then it will be treated by a function dedicated to saving these values in the corresponding tables. This function submits all provided data to the model of the table in order to verify that the proposed values correspond to the format defined for each field. If the user tries to insert data in a different format, the information will not be saved and an error message will appear.

**2.2 Data import and export: PhpExcel**

The tools to import and export spreadsheet files have been developed from a PHPExcel 1.8.0 library, which is integrated to the base as a package. It enables reading, writing and creating spreadsheet files under several formats.

For us, it was of vital importance to ensure the possibility to add the provided data directly into other types of support. This functionality is guaranteed for the main tables; secondary tables have a small number of entries. Thus, for the main tables, data can be imported from spreadsheet files through the creation of a visible element (upload), which is associated to an action in the controller (action\_upload), and allows the user to affect the columns of the file s/he designed in different fields of the selected table. Another function (uploaded data), is executed as



```

<?php

//Declaring an array
$array[] = array('id' => 0, 'value' => 10);
$array[] = array('id' => 1, 'value' => 20);
print_r($array);

//Will display: Array ( [0] => Array ( [id] => 0 [value] => 10 )
                [1] => Array ( [id] => 1 [value] => 20 ) )

//Accessing the values
$value_0 = $array[0]['value'];
echo "value of line 0 = ".$value_0;

//Will display: value of line 0 = 10

//Creating a loop
foreach ($array as $line):
    echo "value of pointed line = ".$line['value']."<br>";
endforeach;

//Will display:
// value of pointed line = 10
// value of pointed line = 20

//Declaring a variable from the database
$data['table'] = Model_table::find(array('order_by' => array('id' => 'asc')));

?>

```

FIG. 5. EXAMPLES OF ARRAY MANAGEMENT IN PHP.

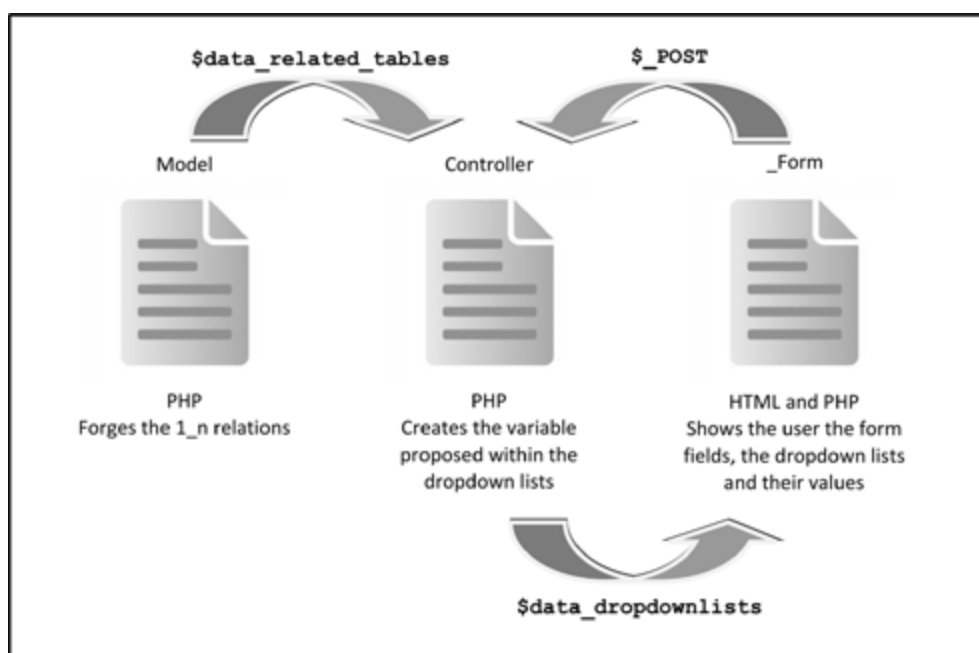


FIG. 6. RELATIONS BETWEEN DIFFERENT SOURCE FILES WHILE CREATING FORM FIELDS.

the visible element is loading. Thanks to the PhpExcel library, this function allows saving the posted file on a temporary location and reading it in order to retrieve the data it contains and to construct a PHP variable (Fig.7a.). Then, for each column identified in the file, the drop-down list of the different table fields will be shown. Once each column has affected a field, the data in each line of the sent file will be compared to the model and then it will be added to the table. There is, nonetheless, an aspect which must be taken into account. The imported file must not contain any empty cell. These must be

necessarily replaced by the value 'NULL' in the case of text type fields and '-1' in the case of number type fields.

Likewise, exporting tables under the excel file format goes through the addition of a new visible element (download), controlled by a function (`action_download`). The variables to be exported are posted from the element which corresponds to their visualisation thanks to a PHP form. This form contains a hidden field which allows sending the variable containing the data in a linear form (thanks to the `serialize` function). It is

```

<?php
//UPLOAD
a. upload function code elements

if(!empty($_FILES))
{
    //Setting the temporary name and temporary location
    $filename = 'uploaded_file.xlsx';
    $tmp_name = $_FILES["my_file"]["tmp_name"];
    move_uploaded_file($tmp_name, DOCROOT.'assets/files/'.$filename);

    //Uploading the file using the PHPEXcel library
    $excel = new PHPEXcel();
    $inputFileName = DOCROOT.'assets/files/uploaded_file.xlsx';
    $inputFileType = PHPEXcel_IOFactory::identify($inputFileName);
    $objReader = PHPEXcel_IOFactory::createReader($inputFileType);
    $objReader->setReadDataOnly(true);
    $objPHPEXcel = $objReader->load($inputFileName);
    $sheet = $objPHPEXcel->getSheet(0);
}

//DOWNLOAD
b. download function code elements

$objPHPEXcel = new PHPEXcel();

$head = array('id', 'label_1', 'label_2', 'label_3');

//head
$head_col = 0;
foreach ($head as $col):
    $objPHPEXcel->getSheet()->setCellValueByColumnAndRow($head_col, 1, $col);
    $head_col++;
endforeach;

//body
$body_line = 2;
foreach ($data['requetes'] as $line):
    $body_col = 0;
    foreach ($line as $cell):
        $objPHPEXcel->getSheet()->setCellValueByColumnAndRow($body_col, $body_line, $cell);
        $body_col ++;
    endforeach;
    $body_line ++;
endforeach;

//Writer
$objWriter = new PHPEXcel_Writer_Excel2007($objPHPEXcel);
$objWriter->save(DOCROOT.'assets/files/downloaded_file.xlsx');
?>

```

FIG. 7. PARTS OF THE UPLOAD AND DOWNLOAD FUNCTIONS CODE INVOLVING THE PHPEXCEL LIBRARY.

possible then to write the document, to save it on a temporary location and to request its download from a visible element thanks to the functionalities of the library (Fig. 7b).

### 2.3 Query interface

The creation of a query interface adapted to palynologist's issues constituted one of the most important goals of the ABCData project. One of the prior concerns about it was to guarantee on one side the possibility to have numerous parameters of queries while being able at a later stage to add some more developments (and especially to include anthracological queries), and on the other side the accuracy of the results. Results have been permanently checked using the local RDBMS query results (Maguet 2013).

To build up this query interface, we added to the original MVC a new set of source files, including new controllers, models and views. Users can select a great amount of parameters to run their queries, then the base computes the results to be displayed, and offers one to download the table or to see the results on the form of a graph.

### 2.4 Query fields management

The query interface shows the user a list of parameters he can select in order to study the effect of this parameters selection on the global results. The view that manages this selection is deeply associated to a javascript file which handles the interactions between the user and the base (for example with dropdown lists, checkboxes, etc.). All parameters are linked to information available about samples, cores, sites, datings or taxa, or even calculation methods (tab. 1).

### 2.5 Calculation of the results

The calculation of the results necessitated the creation of a great number of new functions, added to the controller. First of all, all the values corresponding to the selected criteria and all the primary keys of the sample responding to these criteria must be identified and isolated. If the samples must be classified according to their chrono-cultural attribution, a specific function orders these chrono-cultural periods so that they will appear in a consistent way on a temporal axis.

<p><b>Characteristics of the samples location</b></p> <ul style="list-style-type: none"> <li>Alluvial basin</li> <li>Altitude</li> <li>Sediment nature</li> <li>Palynological context (river bed, swamps, archaeological site...)</li> <li>Distance to the nearest archaeological site</li> </ul>	<p><b>Calculation methods</b></p> <ul style="list-style-type: none"> <li>Vary the taxa excluded from the sum base (i.e. the total number of pollen grains)</li> <li>Express the results in quantity of pollen grains or in % of the sum base</li> <li>Express the results in % of the samples in which the selected taxa are lower or higher to a given quantity.</li> <li>Express the results for each selected taxa or sum the results of all the taxa</li> </ul>
<p><b>Chronological attributions</b></p> <ul style="list-style-type: none"> <li>Lower and upper chronological boundaries</li> <li>Chrono-cultural period(s)</li> </ul>	<p><b>Selection of the taxa</b></p> <ul style="list-style-type: none"> <li>By name</li> <li>By group (heliophytic, ruderals...)</li> <li>By type (woody plants, grass plants, ferns...)</li> </ul>
<p><b>Quality of the samples</b></p> <ul style="list-style-type: none"> <li>Preservation rating</li> <li>Diversity</li> <li>Relative diversity</li> </ul>	<p><b>Clustering queries</b></p> <ul style="list-style-type: none"> <li>By chrono-cultural period(s)</li> <li>By alluvial basin</li> <li>By distance to the nearest archaeological site</li> <li>Palynological context</li> </ul>

TAB. 1. PARAMETERS DISPLAYED IN ABCDATA'S QUERY INTERFACE.

The values corresponding to the rate of each plant among each sample is recalculated depending to the sum base parameters, and several functions are in charge of the reliability and representation evaluations.

One of the biggest issues concerning this kind of programming work is to take into account all the values that can be possibly chosen for each parameter. In order to simplify these numerous possibilities management, a specific function was designed, its role is to analyze the chosen parameters list and to build a variable that turns all the parameters into a set of numeral codes. Depending on these codes, the different functions that must be run to compute the results will not be the same for each query.

### 2.6 Display of the charts

Different kind of graphic representation (Fig. 8) that had to undergo a specific programming phase, are supported by ABCdata. The type of graphic representation known as pollen diagram generally corresponds to the analysis of a sedimentary core in which different samples have been isolated at different depths. But here, the data to be represented are obtained from queries that combine the results of several cores. This does not allow using depth as an axis of the graph. Nevertheless, in many cases, queries show results according to well-defined chronological periods, which can be placed on a time axis. Therefore, values to be shown do not correspond to exact points but to intervals, hence its representation as a histogram. Furthermore, graphics obtained from these queries contain a significantly higher number of taxa than that of a single sequence. The way it is presented on a website, needs an adapted solution. The setting of this tool begins with the creation of a php files group (controller, model, view), associated with a javascript file stored in the `./../public/assets/js` directory. Same as with exporting spreadsheet files, the results of the queries are linearized and sent through a hidden form.

The functions of the controller are designed to define the variables that are later used by the javascript file. Once the php variables are declared in the controller, it is necessary to declare them in javascript, in the view. A tag which will work as a support for the construction of the graph is inserted, and then a script is opened so as to write on it. This procedure corresponds to the javascript language. We also use an online javascript library, `D3.js`, called in the template file. This library allows us to use the data corresponding to the query results as a material for the construction of a *Scalable Vector Graphic* (SVG) that represent these results. Finally, by doing a *mouseover*, it is possible to read the values of the different histogram windows. In order to export these graphs, a plugin such as SVG Crowbar proves to be an excellent solution. The `.svg` files, once they have been downloaded, can be opened and edited with Inkscape.

### 3 Database testing

The functioning of the base was tested through a series of queries we run after the integration of a great amount of palynological data coming essentially from the research work of Chantal Leroyer (UMR 6566 Rennes). All the palynological records we integrated to ABCData have therefore already been analyzed and commented (Leroyer 1997; Leroyer and Allenet de Ribemont 2006), allowing us to compare ABCData's results to the previous numerous publications. Furthermore, the exploitation of these data places itself among a vivid research dynamic supported by the remarkable quantity of palynological and archaeological data available in this region, due to the importance of rescue archaeology surveys in this area.

#### 3.1 Palynological integrated data

Altogether, 31 sites which are mainly located in three different valleys (Oise, Marne and Seine) have been recorded (Fig. 9). In these locations 43 cores were removed, not in the archaeological

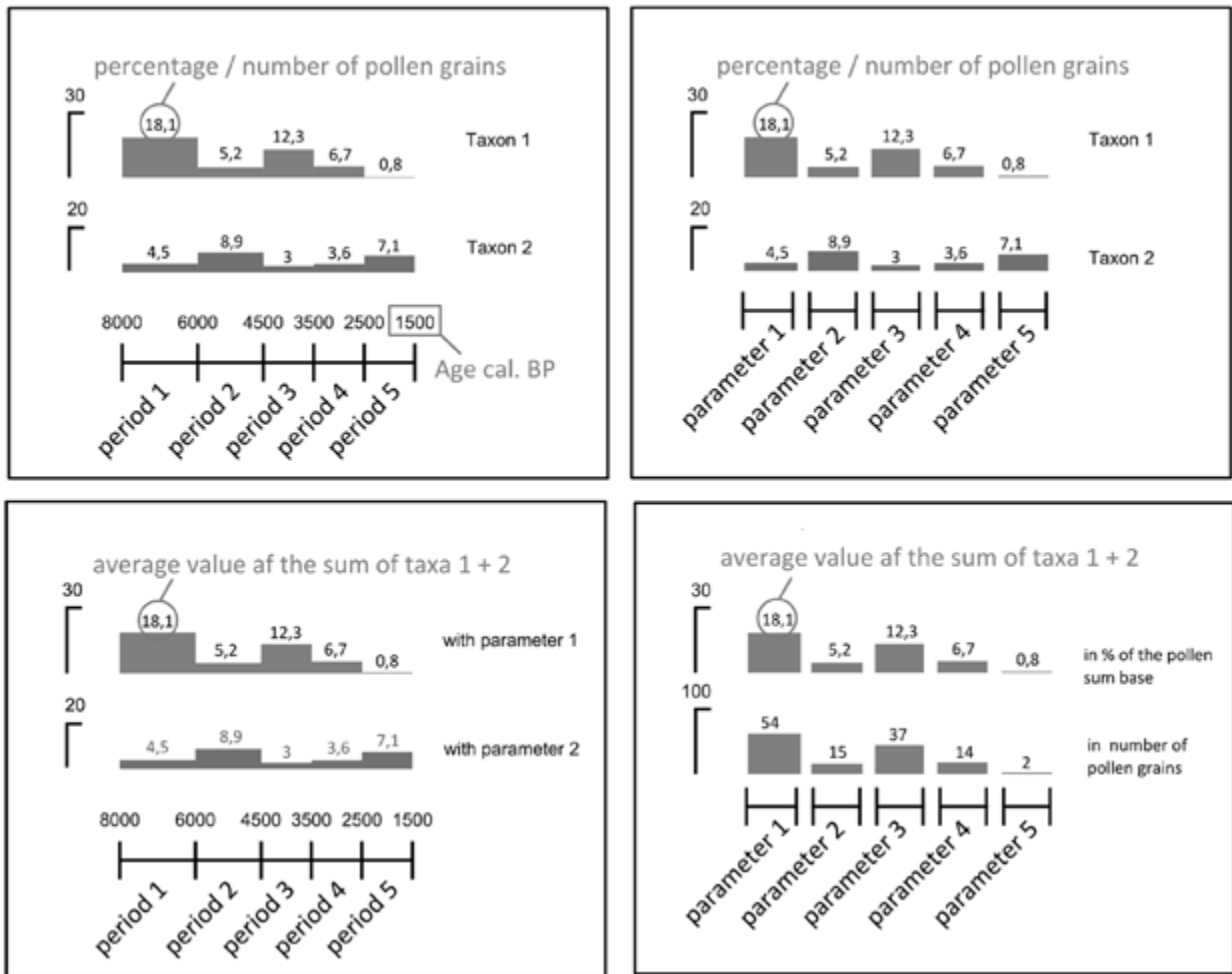


FIG. 8. THE DIFFERENT DIAGRAMS DISPLAYED IN ABCDATA'S QUERY INTERFACE.

sites themselves but in more suitable contexts, mainly in valley-bottom infilling contexts. They represent a total of 996 samples that have been considered as reliable and associated to a chrono-cultural period (tab. 2). This chronological attribution is firstly set on the pollen-assemblage zone (PAZ), but also on various dating methods (<sup>14</sup>C, dendrochronology, archaeological remains), as well as age-depth models (David, 2014). We characterized 32 chrono-cultural periods (annexe 2), their age is defined in calibrated BP, and that may be replaced in a larger context corresponding to the local pollen-assemblage zones identified in the area (Leroyer 1997), and to the Mangerud's chronozones (Mangerud *et al.* 1974) calibrated in B.C. (Walnut and Nalepka 2010).

The sample distribution has also been studied according to the periods and the distances between the collecting area of the samples and the nearest attested archaeological site (Fig. 10).

### 3.2 Results produced

The exploitation of the data through the query interface, associated to the chart displaying tool, enabled us to obtain the synthetic diagrams showing the evolution of all vegetation taxa within a period from the end of the Late Glacial Period (12350 cal. BP) to the middle of the 19th century. On the diagrams

presented here (Fig. 11; Fig. 12), we have chosen to represent only the major or the particularly significant taxa concerning the history of the evolution of the vegetation cover.

The results of this study were compared to the data already published on the history of the vegetation in the Paris Basin (Leroyer 1997; David *et al.* 2012; David 2014) and especially to numerous works focused on the identification of ancient marks of anthropization of the natural landscape (Leroyer 2004; Leroyer 2009; Leroyer and Allenet de Ribemont 2006; Leroyer *et al.* 2012; Leroyer *et al.* 2014). They constitute a statistical synthesis of the totality of the available data, and as such they provide precious information about the evolution of the proportion of the different taxa throughout time. Nevertheless, they should not be considered as a quantitative restitution of the vegetation cover composition during the Holocene Period, that only the modelling studies of the pollinic data may approach. However, these synthetic results are enhanced with the results of queries allowing us to isolate some samples or to carry out different statistical reasoning, more adapted to palaeoenvironmental questionings. The distribution of the available samples according to the chrono-cultural period and the distance in relation to the settlements also constitute an important source of information allowing us to qualify or to explain some observations.

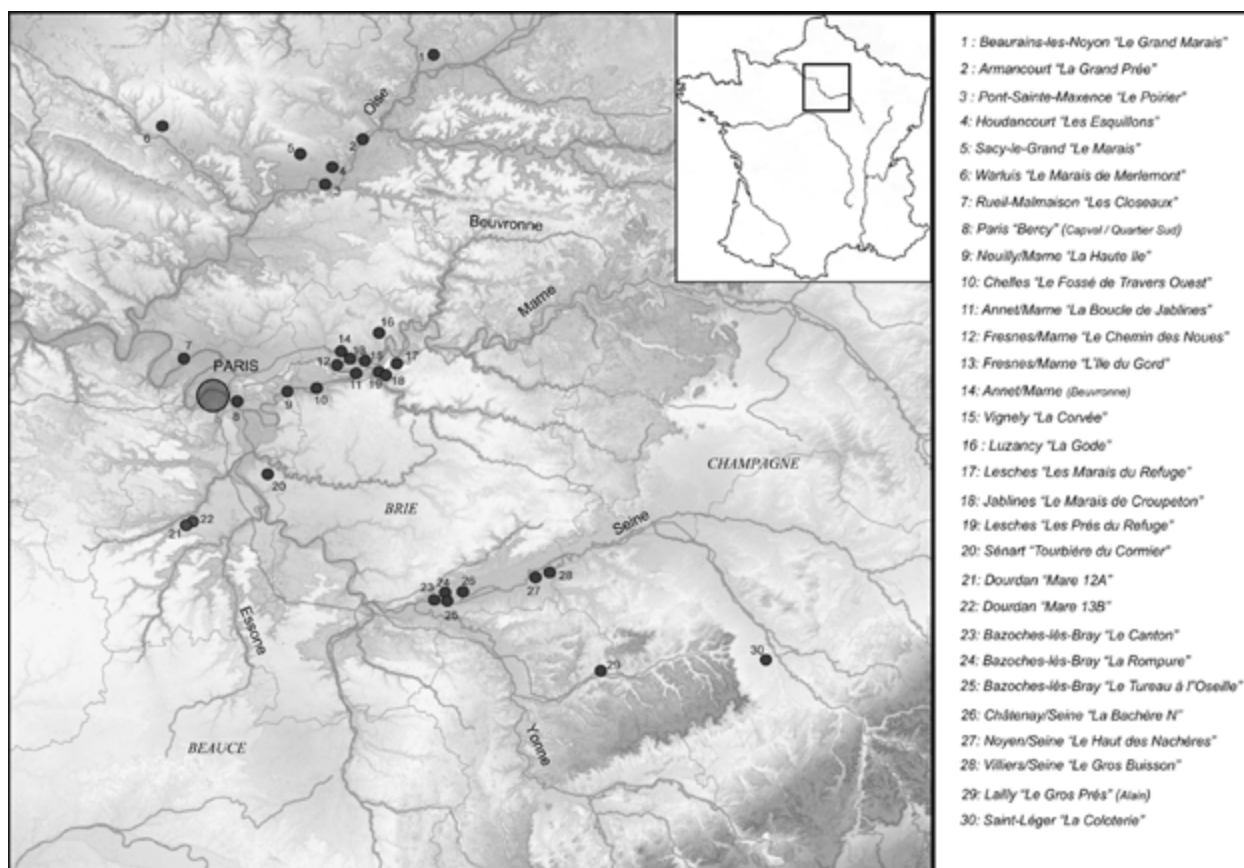


FIG. 9. LOCATIONS OF THE DIFFERENT PALYNOLOGICAL CORES INTEGRATED INTO THE BASE.

#### 4.1 Mesolithic Period

The records corresponding to the end of the Late Glacial Period and to the Mesolithic times send back a quite expected picture of the vegetation evolution, with firstly an open field landscape associated to steppe vegetation. Then the transition to the Preboreal period is clearly marked by a forest recapture stage led by heliophytic taxa, mainly the birch (*Betula*) and the pine (*Pinus*). From the Early Atlantic, corresponding to the transition between medium and recent Mesolithic in the Paris Basin, a remarkable phenomenon can be observed: the queries studying the average of ruderal vegetation show us that in the samples collected less than 100m from an attested human settlement, the rates of ruderal species can reach more than 8%, whereas they are usually included between 2.5 and 3.5% among the other samples (Maguet 2014). These differences could then reveal the mark of a very light form of anthropization of the landscape that can only be observed at immediate proximity of human occupations. However, the traces of cereals in samples assigned to the Late Mesolithic could show a vice of designation or a problem of chronological assignation of the samples. The final stages of the Mesolithic period can in fact be sometimes contemporary of the arrival of the first Danubians (Leroy *et al.* 2014).

#### 4.2 Neolithic Period

During the Neolithic times, no disturbance of the woody plants, nor noticeable increase of pollinic evidences of anthropization can be detected, although the presence of cereals pollens leaves

no doubt about the existence of agricultural activities. The study of the assemblages in accordance with the distance to the human occupation shows us again that the recording of ruderals and cereals is much more important near the sites. This is what notably explains the importance of the ruderals (more than 5%) in the Chasséen-Michelsberg Kultur, period for which about half the samples are located less than 100 meters far from an archaeological site (Maguet 2014). These elements therefore speak in favour of the hypothesis of an anthropogenic impact perceptible as soon as the earliest Neolithic groups settle down, but effective and observable only on local scale. The environment during this period seems therefore relatively open, although the main woody plants keep an important part, and the traces of the cereal agriculture remain low. Furthermore, it is important to note that the first farming exploitation methods and their environmental impact are still not well known. It is more likely that a part of the agro-pastoral activities of the Neolithic period have left very few traces in the palynological records. Especially the semi-nomadic agricultural techniques called slash and burn, that places the crops in the middle of a mass of forest acting as a filter and stimulates the renewal of the forest areas, have few chances of being detected only by means of palynology (Vuorela 1986). Finally, the filter put upon these data by the expansion of the alder during the Late Atlantic, which has an affect both during the material dropping in ponds surrounded by the waterside woodland, and also during the calculation of the results in percentage of the sum base (Leroy 1997; Leroy and Allenet de Ribemont 2006), creates a further obstacle to the identification of the first landscape disruptions.

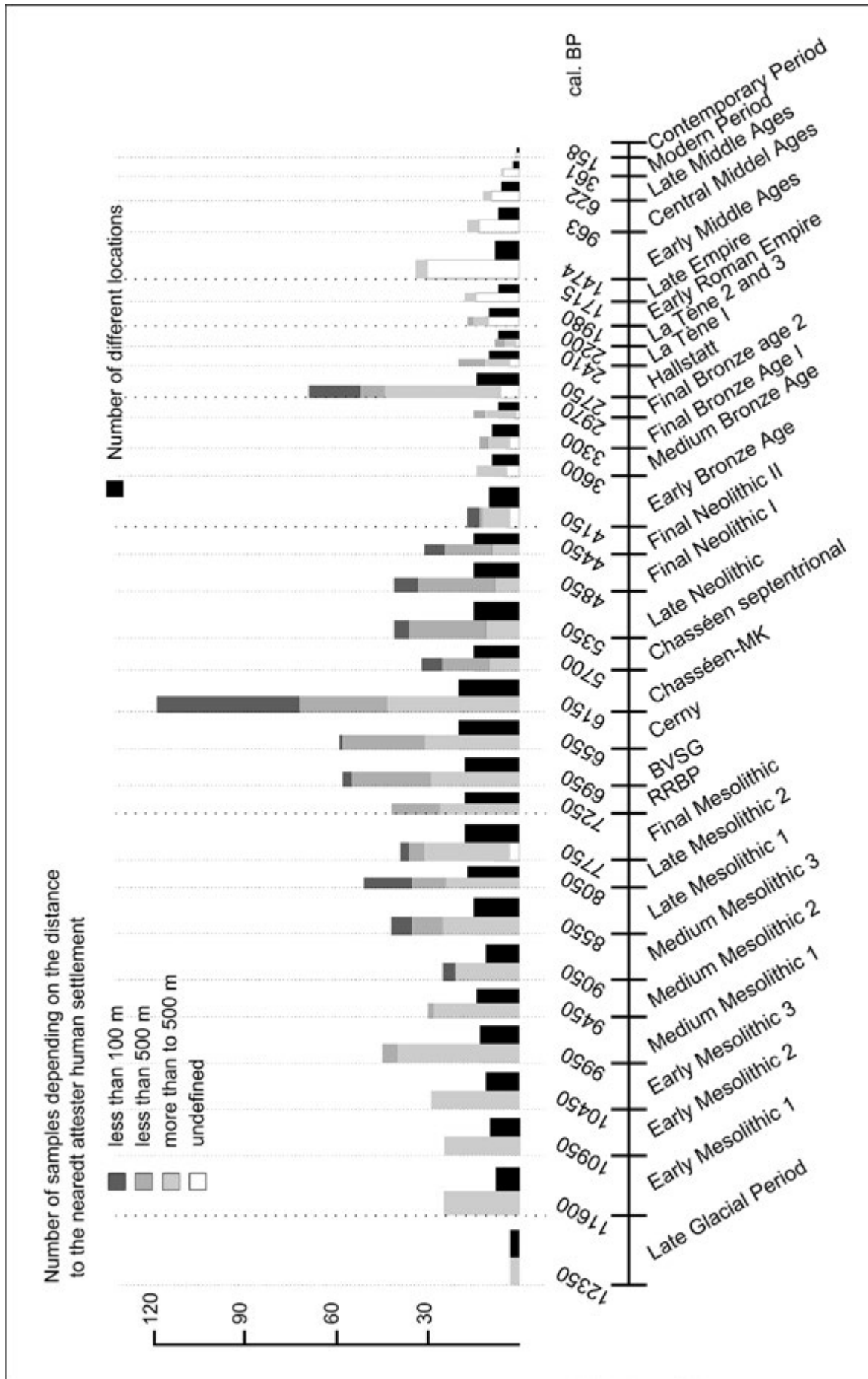


FIG. 10. DISTRIBUTION OF THE SAMPLES INTEGRATED INTO THE BASE.

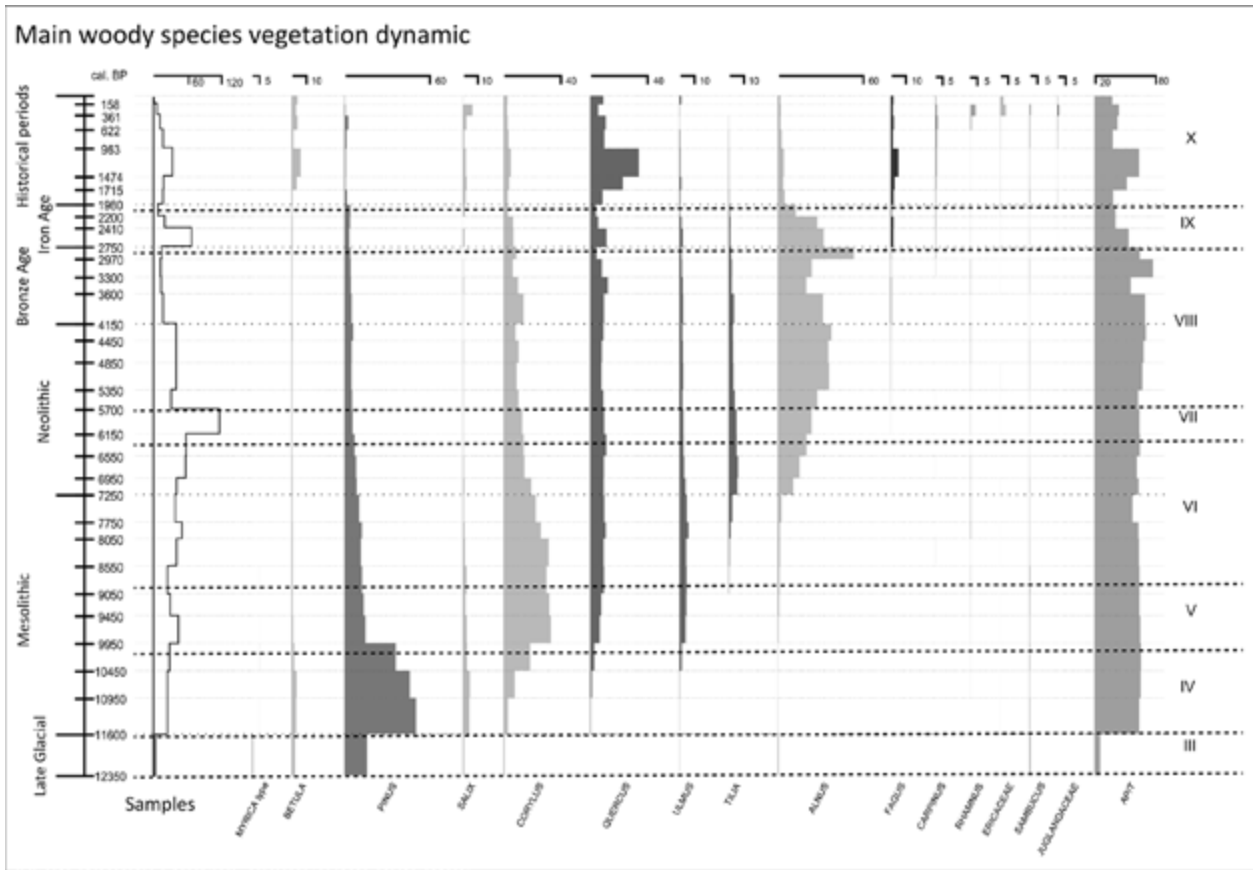


FIG. 11. PALYNOLOGICAL DIAGRAM OF THE MAIN WOODY SPECIES.

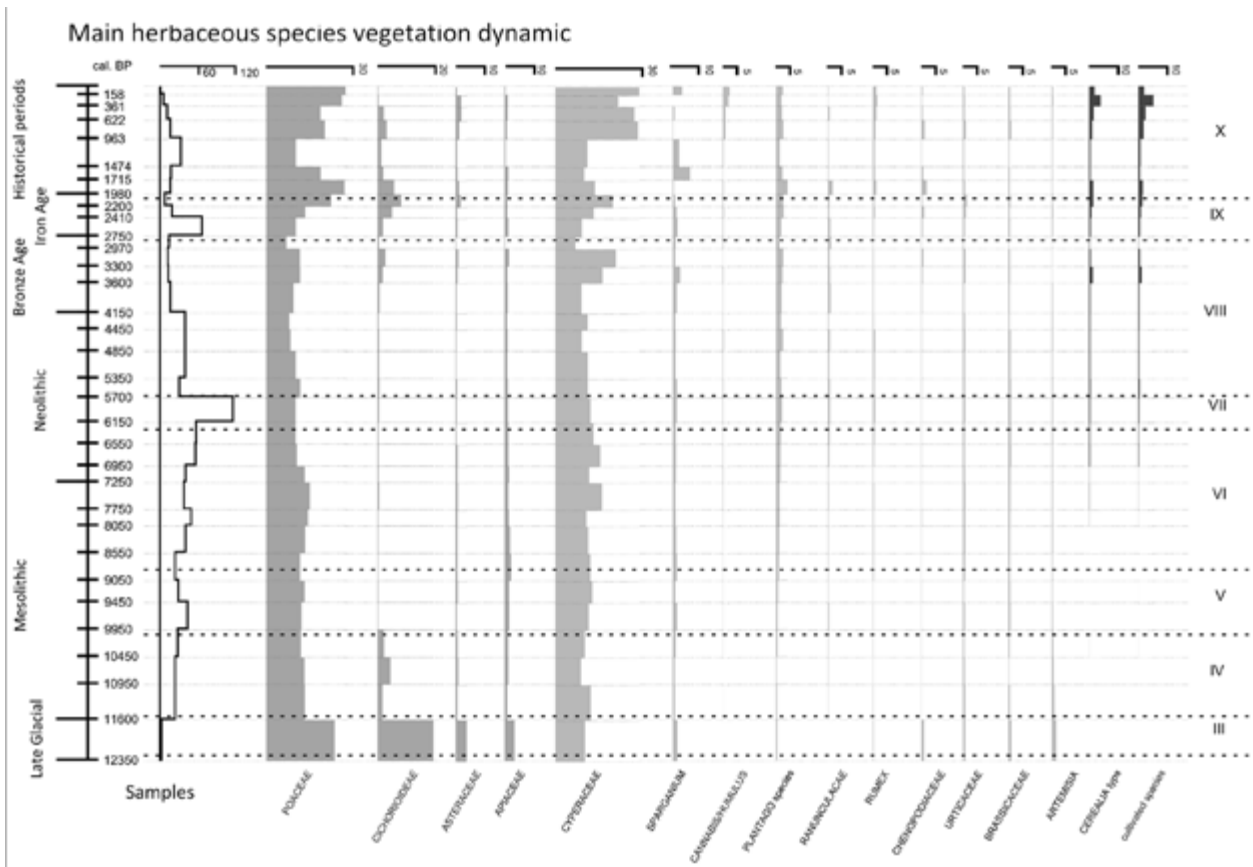


FIG. 12. PALYNOLOGICAL DIAGRAM OF THE MAIN HERBACEOUS SPECIES.

Dates cal. BP	PAZ	Chronozones (Mangerud and al. 1974)	Chrono-cultural periods of reference	Dates cal. BC/AD	
	X	Subatlantic	Contemporary period	1950	
			Modern period	1792	
			Late Middle Ages	1474	
			Historical Periods	Central Middle Ages	1328
			Early Middle Ages	987	
			Late Roman Empire	476	
			Early Roman Empire	235	
-2050			IX		La Tène 2 and 3
	La Tène 1	-250			
-2850	VIII	Subboreal	Hallstatt	-460	
			Final Bronze Age 2	-800	
			Final Bronze Age 1	-1020	
			Bronze Age	Medium Bronze Age	-1350
			Early Bronze Age	-1650	
			Final Neolithic	-2200	
			Final Neolithic 2	-2500	
			Final Neolithic 1	-2500	
			Late Neolithic	-2900	
-5750	VII	Late Atlantic	Chasséen septentrional	-3400	
			Central Neolithic	Chasséen-MK	-3750
				Cerny	-4200
			Early Neolithic	-4600	
			BVSG	-5000	
-6350	VI	Atlantic	RRBP	-5300	
			Final Mesolithic	-5600	
			Late Mesolithic	-5600	
			Late Mesolithic 2	-6100	
			Late Mesolithic 1	-6100	
			Medium Mesolithic 3	-6600	
-8950	V	Boreal	Medium Mesolithic	Medium Mesolithic 2	-7100
				Medium Mesolithic 1	-7500
-10150	IV	Preboreal	Early Mesolithic	-8000	
			Early Mesolithic 2	-9000	
-11450	III	Late Dryas	Early Mesolithic 1	-9000	
-12950	II	- Early sup. Dryas	Quaternary/Late Glacial	-9650	
-13650	I		Alleröd	-10400	
-13600			Bölling		
			Late Glacial Period		
			Late Glacial		
				-16050	

TAB. 2. CHRONO-CULTURAL PERIODS AND CHRONOZONES OF REFERENCES.



### 4.3 Bronze Age

From the Bronze Age, a smaller number of samples are available, and we know less about the population of the Paris Basin during this period. The synthetic diagrams prove us a relative continuity between the Neolithic period and the Early Bronze Age, with only a short rise of the hazel (*Corylus*) noticeable at less than 100 meters from the sites (Maguet 2014). This may show a short phase of forest recovery, or eventually new forms of forest management (David 2014). Indeed, together with the increasing growth of the hazel, important rates of the nitrophilic group can be observed. The move to the Medium Bronze Age is branded by a slight increase of the poaceae averages, which suggests a dynamic of landscape opening or woodland clearing, the poaceae being eventually able to grow among lightly thick forest areas (Leroyer 1997). Otherwise we can notice an increase of recorded cereal (*Cerealia* type) quantities as well as a greater proportion of samples in which the cereal ratio is higher than the 1% threshold, even though it happens to be samples to which no nearby settlement is connected. During the Medium Bronze Age, the sudden decrease of cereal quantities seems startling. Actually the explanation of these values comes from a lack of sample diversity: half of them come from a unique site consequently carrying a disproportionate weight in the averages calculation (Maguet 2014). This point highlights an important bias which puts in evidence the necessity of a stronger development of the means of controlling the distribution and the representativeness of the samples, in order to regulate the synthetic results. Keeping in mind these reticences about the reliability of the study bearing on the 2nd Final Bronze, it looks as if the end of Subboreal period could correspond to a stage of wood plants destabilization revealed by the forest and heliophytic vegetation decrease. To sum up, the Bronze Age appears therefore printed by a better perception of anthropization evidences suggesting reinforcement of human grip on the environment, a rise of farming lands or even a use of forest resources for metallurgy (Leroyer 1997). Though no samples closely related to an archaeological settlement after the Early Bronze Age can be found, the recording of the varied IPAs tends to reinforce this hypothesis.

### 4.4 Iron Age and Historical times

If the samples associated to the Hallstatt culture constitute a quite satisfying corpus, they are less numerous and more disconnected with the archaeological sites of the 2nd Iron Age. Nevertheless the transition to the Subatlantic period around 600 cal. BC corresponds to the beginning of a dynamic which will last until the end of the Early Roman Empire. It starts with a quick withdrawal of alder linked to the expansion of the beech tree and of the opening of the landscape, colonized by *Poaceae* and *Cichorioideae*, opening realized against most of the wood plants to the exception of the hornbeam (*Carpinus*) which slightly gains ground. At the beginning of the Gallic period, the timid presence of new crops such as fax, rye, walnut, and vine can be noticed. It is mainly from the beginning of the La Tène culture that a significant increase of the cereal percentage is recorded (Maguet 2014).

Between the Early and the Late Roman Empire, a very clear break is characterized by the lessening of crops excepting rye (*Secale* type) and chestnut (*Castanea*) as well as ruderals, together with a very clear increase of the oak and the heliophytic plants. Therefore the dynamic initiated since the Bronze Age

seems then to invert as a new growth of forest vegetation can be observed. The rates of the heliophytic plants (*Corylus* and *Betula*), correlated to the weakness of anthropization indicators confirms a recovery of the environment by these pioneering vegetation. The ruderal assemblage composition and the low averages of *Cerealia*, suggest a predominance of pastoralism as the main agricultural activity until the High Middle Age, in accordance with the expected results (Leroyer, 1997). From the Carolingian times an increase of all the crops and pastures (dry or damp) can be observed. This tendency persists from the Early Middle Age to the 20th century, with a drop of *Castanea* and *Secale* type to the benefit of *Cerealia* type which confirms its supremacy among the cultivated taxa. Nevertheless the poverty of the available sample corpus for the more recent periods forbids any further interpretations.

### 5 Conclusion

With this project, we aimed to open new perspectives for the development of palaeoenvironmental field, as the archaeologists are more and more interested in reconstructing the past ecosystems, understanding the evolution of animals and plants, and comprehending the role of human societies within the natural landscape.

The creation of ABCData, from the base programming to the analysis of the integrated data, allowed us to evaluate the interest computer programming could bring to our domain, and to get a better estimation of the advantages, requirements and issues of this application. Now we must highlight the complexity of the program writing and the weight of the IT resources used notably for the query results computing with the php language. Consequently, the results must always be cautiously considered before validation. We also discovered new possibilities in terms of storage, exploitation and visualisation of the results. The integration of information about the samples, together with the paleobotanical data, allows us to run queries that study the impact of some influent parameters in order to try out some hypothesis and explain some phenomena. It particularly pointed out the misrepresentation of the global results caused by unbalanced distributions of the samples.

Interdisciplinarity is also an essential element that still has to be developed, particularly concerning the comparison between palynological and anthracological data. That confrontation has already proved to be fertile (Leroyer *et al.* 2011). Besides, the archaeozoological part is currently being developed, and on the long term ABCData should be able to host malacological data. It would also be interesting to integrate into the base a larger quantity of data, from other areas or attributed to other periods, in order to run queries involving new parameters. Finally, GIS interface will soon be added to the base and we would like to be able to explore the graphic possibilities offered by the D3.js library and to consider the creation of a 3D landscape reconstruction tool.

### Bibliography

David, R., Leroyer, C., Mazier, F., Lanos, P., Dufresne, P., Allenet De Ribemont, G., Aoustin, D. 2012. Les transformations de la végétation du bassin parisien par la modélisation des données polliniques holocènes. In Bertonecello, F. and Braemer, F. (eds.), *Variabilités environnementales, mutations sociales. Nature, intensités,*

- échelles et temporalités des changements. Actes des XXXIIe rencontres internationales d'archéologie et d'histoire d'Antibes*: 53-68. Antibes, Éditions APDCA.
- David, R. 2014. *Modélisation de la végétation Holocène du Nord-Ouest de la France : Reconstruction de la chronologie et de l'évolution du couvert végétal du Bassin parisien et du Massif armoricain*. Unpublished PhD thesis, Université de Rennes 1.
- Goëury, C. 1997. GpalWin : gestion, traitement et représentation des données de la paléoécologie. In *Actes du XI<sup>e</sup> symposium de l'A.P.L.F.* : 31. Lyon.
- Kreuz, A. and Shafer, E. 2002. A new archaeobotanical database program. *Vegetation History and Archaeobotany* 11: 177-9.
- Leroyer, C. 1997. *Homme, climat, végétation au Tardiglaciaire dans le Bassin parisien : apport de l'étude palynologique des fonds de vallée*. Unpublished PhD thesis, Université Paris 1 Panthéon-Sorbonne.
- Leroyer, C. 2004. L'anthropisation du Bassin parisien du VIIe au IV millénaire d'après les analyses polliniques des fonds de vallées : mise en évidence d'activités agro-pastorales très précoces. In Richard, H. (ed.), *Néolithisation précoce. Premières traces d'anthropisation du couvert végétal à partir des données polliniques*, Collection Annales littéraires, série 'Environnement, Sociétés et Archéologie' 7: 11-27. Besançon, Presses Universitaires de Franche-Comté.
- Leroyer, C. and Allenet De Ribemont, G. 2006. L'anthropisation du paysage végétal d'après les données polliniques : l'exemple des fonds de vallées du Bassin parisien. In P. Allée and L. Lespez (eds.), *L'érosion, entre société, climat et paléoenvironnement* : 63-72. Clermont-Ferrand, Presses Universitaires Blaise Pascal.
- Leroyer, C. et al. 2009. Base de données et S.I.G. palynologiques sur l'Age du Fer en France : une autre approche du paysage végétal et de son anthropisation. In I. Bertrand, A. Duval, J. Gomez De Soto, P. Maguer (eds.), *Habitats et paysages ruraux en Gaule et regards sur d'autres régions du monde celtique. Actes du XXXIe colloque international de l'Association Française pour l'Etude de l'Age du Fer, Chauvigny, 17 - 20 mai 2007*, II, Mémoire A. P. C. XXXV: 447-68.
- Leroyer, C., Coubray, S., Allenet de Ribemont, G., Perrière, J., Pernaud J.-M. 2011) Vegetation dynamics, human impact and exploitation patterns in the Paris Basin through the Holocene: palynology vs. Anthracology. *SAGVNTVM* 11: 81-2.
- Leroyer, C., David, R., Mazier, F., Allenet de Ribemont, G., Lanos, P., Dufresne, P. (2012) Environnement et anthropisation du milieu durant l'âge du Bronze dans le Bassin parisien : l'apport des données polliniques et de la modélisation du couvert végétal. In Melin, M., Mougne, C. (eds.), *L'Homme, ses ressources et son environnement dans le Nord-Ouest de la France à l'âge de Bronze : actualités de la recherche. Actes du Séminaire Archéologique de l'Ouest*: 7-26. Rennes.
- Leroyer, C., David, R., Maguet, E., Mazier, F., Allenet de Ribemont, G., Lanos, P., Dufresne, P. 2014. *Environnement et anthropisation du milieu durant le Néolithique dans le Bassin parisien : l'apport des données polliniques et de la modélisation du couvert végétal* (in press).
- Maguet, E. 2013. *Création et exploitation d'une base de données palynologiques sur le Mésolithique et le Néolithique du Bassin parisien*. Rennes, Mémoire de Master 1 « Histoire et Archéologie », Université de Rennes 2.
- Maguet, E. 2014. *Mise en ligne d'une base de données paléoenvironnementales : développement et applications*. Rennes: Mémoire de Master 2 « Paléontologie, Préhistoire, Paléoenvironnements », Université de Rennes 1.
- Mangerud, J., Andersen, S. T., Berglund, B.E., Donner, J. 1974. Quaternary stratigraphy of Norden, a proposal for terminology and classification. *Boreas* 3, 3: 109-26.
- Reille, M. 1990. *Leçons de palynologie et d'analyse pollinique*. Paris, Éditions du CNRS.
- Tomlinson, P. 1992. Design and implementation of a relational database for archaeobotanical records from Great Britain and Ireland. *Circaea, The Journal of the Association for Environmental Archaeology* 10, 1: 1-30.
- Vuorela, I. 1986. Palynological and historical evidence of slash-brun cultivation in South Finland. In Behre, K. E. (ed.), *Anthropogenic indicators in pollen diagrams*: 53-64. Rotterdam, A. A. Balkema.
- Walanus, A., Nalepka, D. 2010. Calibration of Mangerud's boundaries. *Radiocarbon* 52, 4: 1639-44.