



9th Developing International  
Geoarchaeology Conference  
**University of the Algarve**  
**Faro, Portugal**

BOOK OF ABSTRACTS

## DIG2021 CONFERENCE PROGRAM

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	<a href="#"><u>Session 1</u></a> 9:10-9:50 am	<p><b>[1] Conor McAdams, M.W. Morley and R.G. Roberts</b> New insights into the Pleistocene archaeology of mainland Southeast Asia: understanding tropical cave sediments through microstratigraphic site investigations and laboratory experiments</p> <p><b>[2] Meghan McAllister, M.W. Morley, J.J. Tyler, F.A. McInerney and A.J. Blyth</b> Leaf waxes &amp; lipid biomarkers: reconstructing the palaeoenvironments experienced by early H. sapiens across Southeast Asia &amp; Australia</p> <p><b>[3] Natasha Nagle</b> Sediment fingerprinting: identifying sedimentological characteristics and formation processes at Late Pleistocene archaeological sites in Southeast Asia and Australia</p> <p><b>[4] Vito Hernandez, M. Morley, P. Düringer, J-L. Ponche, K. Westaway, A-M. Bacon, L. Shackelford, V. Souksavady and F. Demeter</b> Early Human Occupation of Tam Pa Ling, Laos: Preliminary Microstratigraphic Results</p> <p><b>Questions &amp; Discussion</b></p>
	<a href="#"><u>Session 2</u></a> 10:00-10:50 am	<p><b>[5] Xiaolin Ren, D. Mo and M.J. Storzum</b> Climate change, landscape evolution and settlement distribution patterns in the Shuangji River valley, Central China, since the Upper Paleolithic</p> <p><b>[6] Aristides Varis, C.E. Miller, P. Cuthbertson, A. Namen, Z. Taimagambetov and R. Iovita</b> Micromorphology in a survey context: insights from cave survey in South Kazakhstan</p> <p><b>[7] Natàlia Égüez, M. Jambrina-Enríquez, O. Seitsonen, L.G. Broderick, J. Bayarshaikhan and J-L. Houle</b> Application of compound specific stable isotope analysis in sediments for tracing environmental changes. A 4000 BP multiperiod habitation site in the Züünkhangaï region (Mongolia)</p> <p><b>[8] Yashaswini Jayadevaiah, U. Misra, A. K. Basantray, C. Athul, A. Mandal and K. Patil</b> Preliminary findings of the micro-gravity study at Śṛīṅgaverapura, India: a 2000-year-old water harvesting tank system</p> <p><b>Questions &amp; Discussion</b></p>

Mon. May 17	<p><b><u>Session 3</u></b> 11:00-11:50 am</p> <p><b>[9] Sally Hoare, R.M. Albert, I.G. Stanistreet, H. Stollhofen, S.M. Rucina and J.A.J. Gowlett</b> New archaeological sites from Kilombe Caldera, Kenya: site formation and palaeoenvironmental context of hominin occupation in a highland setting</p> <p><b>[10] Michael B. Toffolo</b> Geoarchaeology of Pleistocene open-air sites in the central interior of South Africa</p> <p><b>[11] Kristen Wroth, B. Bousman, C. Tribolo, L. Rossouw, C.E. Miller and M.B. Toffolo</b> Micromorphology and phytolith analysis from the Middle-to-Later Stone Age site of Lovedale, Free State, South Africa</p> <p><b>[12] Aviad Agam, T. Rosenberg-Yefet, L. Wilson, M. Shemer and R. Barkai</b> Flint type analysis from Late Acheulian Jaljulia (Israel), and possible implications for the origins of the Levallois method</p> <p><b>Questions &amp; Discussion</b></p>	
	<p><b><u>Session 4</u></b> 2:00-2:50 pm</p> <p><b>[13] Alyssa Victoria Pietraszek, Y. Zaidner and R. Shahack-Gross</b> Use of fire and space at Unit V of the Middle Paleolithic open-air site at Nesher Ramla, Israel</p> <p><b>[14] Lucy Wilson</b> Seasonal territory use in the Middle Palaeolithic of the Vaucluse, southern France.</p> <p><b>[15] Javier Davara, A.V. Herrera-Herrera, M. Jambriña-Enríquez, C.M. Hernández, B. Galván and C. Mallol</b> Lipid biomarker analysis of contextualized lithic remains from El Salt Middle Palaeolithic site (Alicante, Spain)</p> <p><b>[16] Lucia Leierer, A. Carrancho Alonso, L. Pérez, Á. Herrejón Lagunilla, A.V. Herrera-Herrera, R. Connolly, M. Jambriña-Enríquez, C.M. Hernández Gómez, B. Galván and C. Mallol</b> It's getting hot in here – microcontextual study of a potential pit hearth at the Middle Paleolithic site of El Salt, Spain</p> <p><b>Questions &amp; Discussion</b></p>	
	<p><b><u>Session 5</u></b> 3:00-3:40 pm</p> <p><b>[17] Martin Arriolabengoa, J. Ríos-Garaizar, J. Aranbarri, A. Arranz-Otaegui, M.A. Medina-Alcaide, I. Intxaurbe, O. Rivero and D. Garate</b> Final MIS 3 to early MIS 1 sedimentary sequence from Atxurra archaeological site (northern Iberian Peninsula): An approach from micromorphological and mineralogical analysis</p> <p><b>[18] Diana Marcazzan, C.E. Miller, S.M. Mentzer and M. Peresani</b> Geoarchaeological investigation of the Middle to Upper Paleolithic anthropogenic features in Fumane Cave (Italy)</p>	

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	Key-note 3:45-5:00 pm	<p><b>Takis Karkanas</b> Sedimentary structures and fabrics: what we are overlooking</p>
	Ice-breaker 5:00-6:00 pm	Session in <b>Gather.town</b>
Tue. May <b>18</b>	<a href="#">Session 6</a> 9:00-09:50 am	<p><b>[20] Isaac Ogloblin Ramirez, E. Galili and R. Shahack-Gross</b> Underwater micromorphology: A case study of combustion features from the submerged Neolithic sites of the Carmel Coast, Israel.</p> <p><b>[21] Jos Kleijne</b> MicroTRASH: first microscopic insights into Later Neolithic Northern European midden practices</p> <p><b>[22] Rachel Kulick, D. Lewis, C. Atkins, F. Berna, K. Fisher, C. Kearns and S. Manning</b> Geoarchaeology at Bronze Age Maroni Vournes, Cyprus: Micromorphology and Palaeolandscape Analysis</p> <p><b>[23] Federico Polisca, C. Nicosia, C.E. Miller, B. Ligouis, F. Gonzato and C. Mangani</b> Geoarchaeology of daily life: insights on Bronze Age lifeways from the waterlogged site of Oppeano 4D (Verona, Italy)</p> <p><b>Questions &amp; Discussion</b></p>
	<a href="#">Session 7</a> 10:00-10:50 am	<p><b>[24] Guido Stefano Mariani, F. Brandolini, S. Naitza and R.T. Melis</b> Landscape spatial occupation patterns and resource availability in Nuragic Sardinia (Italy): a glimpse of Bronze Age land use strategies.</p> <p><b>[25] Matthieu Giaime, H.M. Jol, Y. Salmon, A. Abu Hamed, G.I. López, L. Bergevin, E. Sailer-Haugland, P. Bauman, A. McClymont and M. Artzy</b> Late-Holocene coastal changes and their effects on settlement/anchorage patterns on Tel Akko (Israel)</p> <p><b>[26] Laura Tomé, M. Jambrina-Enríquez, N. Égüez, A.V. Herrera-Herrera, A. Blanco-González and C. Mallol</b> Early Iron Age olive oil production in Iberia? Microscopic and molecular geoarchaeology at Cerro de San Vicente village (Salamanca, Spain)</p> <p><b>Questions &amp; Discussion</b></p>

<p>Tue. May <b>18</b></p>	<p><a href="#">Session 8</a> 11:00-11:50 am</p>	<p><b>[27] Barbora Wouters and P.L.K. Trant</b> Geoarchaeological research in Ribe's Northern Emporium, Denmark – a micromorphological and geochemical study of a highly stratified urban context, AD 700 – 900</p> <p><b>[28] Mario Gutiérrez-Rodríguez, M.A. Lechuga Chica, M.I. Moreno Padilla and J.P. Bellón Ruiz</b> Multiscalar spatial and geoarchaeological analysis of the main roman road in Hispania. The Via Augusta where it passes through the Ianus Augustus (Mengíbar, Spain)</p> <p><b>[29] Enrique Fernández-Palacios, C. Rodríguez, C.M. Hernández, A.V. Herrera-Herrera, M. Jambrina-Enríquez, J.F. Navarro, E. Marrero, C.E. Miller and C. Mallol</b> Belmaco Cave: an aboriginal fumier deposit on La Palma (Canary Islands)</p> <p><b>[30] Yannick Devos</b> Conquering the Darkness: 20 years of geoarchaeological research on the Dark Earth from the historical centre of Brussels (Belgium)</p> <p><b>Questions &amp; Discussion</b></p>
	<p><a href="#">Session 9</a> 2:00-2:50 am</p>	<p><b>[31] Hans Huisman</b> Lost again? A future for micromorphological thin sections</p> <p><b>[32] Pedro García, R. Arnay, J. Hernández-Aceituno and C. Mallol</b> Soil Micromorphological image classification using Deep Learning: the porosity parameter</p> <p><b>[33] David E. Friesem, N. Teutsch, M. Weinstein-Evron, R. Shimelmitz and R. Shahack-Gross</b> Identification of bat guano and pigeon droppings in archaeological cave sites</p> <p><b>[34] Mareike Stahlschmidt and V. Aldeias</b> A geoarchaeological perspective on ancient sediment DNA from archaeological contexts</p> <p><b>[35] Irini Sifogeorgaki</b> Site formation processes at sandstone and quartzite rockshelters: a geoarchaeological review</p> <p><b>Questions &amp; Discussion</b></p>
	<p><a href="#">Poster session</a> 3:00-4:00 am</p>	<p><b>All posters</b> Session in <b>Gather.town</b></p>
<p>Wed. May <b>19</b></p>	<p><a href="#">Session 10</a> 09:00-09:50 am</p>	<p><b>[36] Katarína Adameková, J. Petřík, L. Petr, P. Kočár, J. Bartík and T. Chrástek</b> Man and a river in the Middle Ages: a unique sequence of floods, human habitation and soil formation on the floodplain of the river Morava</p>

Wed.  
May  
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**[37] Noemí Silva-Sánchez, M. Fernández Ferreiro, E. López-Salas, T. Kinnaid, S. Turner and J. C. Sánchez Pardo**

A dialog between nature and texts. Diachronic evolution of a monastic landscape. A novel application at Samos Abbey (NW Spain)

**[38] Daniel Fallu, P. Zhao and A. Brown**

Geochemical signatures of terrace construction and cultivation: preliminary results of the TerrACE Project

**[39] Tiziana Matarazzo and G. Boenzi**

Micromorphological analysis of agricultural features sealed by several eruptions of the Phlaegrean volcanic system (Campi Flegrei) in Southern Italy

**Questions & Discussion**

### Session 11

10:00-10:50 am

**[40] Joeri Kaal, M. Suárez Abelenda, D. Stump and C. Ferro-Vázquez**

Multiproxy geoarchaeological study of agricultural sediment traps in the Iron Age ruins of Engaruka (Tanzania)

**[41] Carol Lang, T. Kabora, C. Ferro-Vázquez and D. Stump**

Geoarchaeological study of the viability of an abandoned agricultural landscape to once again become productive. The case of Engaruka (N Tanzania)

**[42] Gianni Gallelo, C. Ferro-Vázquez, Á. Hernández Sánchez, M. Ramacciotti, S. Chenery, C. Lang, S. Thornton-Barnett, T. Kabora, M. E. Hodson, A. Morales and D. Stump**

Tracking sedimentary processes through REE geochemistry at an agricultural Iron Age site in N Tanzania.

**[43] Tabitha Kabora, D. Stump and J. Wainwright**

Modelling sediment transport and accumulation in archaeological sites

**Questions & Discussion**

### Session 12

2:00-2:50 am

**[44] Luc Vrydaghs, M. J. Hodson, R. Hermans and Y. Devos**

Do phytoliths become auto-fluorescent upon heating?

**[45] Magnus Haaland, S.M. Mentzer, E.C. Velliky and C.E. Miller**

Characterizing microscopic ochre fragments at Middle Stone Age sites: implications for evaluating *in situ* ochre processing and use

**[46] Virginie Renson, H. Neff, A. Martínez-Cortizas, J.P. Blomster, D. Cheetham and M. Glascock**

Using isotopes of lead and strontium to source ceramics – application in Mesoamerican context

**[47] Andrew Zipkin, M. Hipondoka, P. Le Roux and P. Wiessner**

Radiogenic strontium isoscape construction in the Kalahari and Namib deserts for provenience studies of ostrich eggshell ornaments

<b>Wed. May 19</b>		<p><b>[48] Peter Mears, C. Brown and L. Wilson</b> A growing role for statistics in lithic archaeology</p> <p><b>[49] Nicholas Crabb, C. Carey, A. Howard, R. Jackson, M. Brolly and N. Burnside</b> Remote sensing for the reconstruction and mapping of archaeological resources in alluvial environments</p> <p><b>Questions &amp; Discussion</b></p>
	<p><a href="#">Session 13</a> 2:00-2:50 pm</p>	<p><b>[50] Manuel Arroyo-Kalin, H.P. Lima, M.C.P. Mariano, E.G. Neves and D.K. Wright</b> The micromorphology of Amazonian Dark Earths - a comparative perspective</p> <p><b>[51] Kelly Brandão, L.P. Furquim, X.S. Villagran and E.G. Neves</b> Initial micromorphological and archaeobotanical data for the monticular complex of the southwestern Amazon - Sol de Campinas do Acre</p> <p><b>[52] Justin Holcomb and L-M. Shillito</b> Microarchaeology of the Younger Dryas Cold Event in the Northern Great Basin, USA</p> <p><b>[53] Teresa Matheson, F. Rahemtulla and F. Berna</b> Investigating site formation processes at EjTa-4 on Calvert Island, British Columbia: results from a microstratigraphic study of excavation units 12 and 10/15</p> <p><b>[54] Don Butler, B.A. Potter and J.D. Reuther</b> Geoarchaeology of paleo-Critical Zones expressed in the Mead loess-paleosol sequence, Central Alaska</p> <p><b>Questions &amp; Discussion</b></p>
	<p><b>Closing</b> 3:00-3:30 pm</p>	<p><b>Lucy Wilson</b></p>
	<p><a href="#">Posters &amp; final gathering</a> 3:30 pm</p>	<p><b>All posters</b> Session in <b>Gather.town</b></p>

## List of posters

**[P.1] Opeyemi Adewumi, L. Oosterbeek, M.Q. Ferreira, J.P. Vallverdú and N.J. Almeida**

Sequencing deposits and human occupations at the Early Neolithic site of Salvador (Abrantes, Portugal): preliminary micromorphological assessment.

**[P.2] Phyllida Bailey, M. Azzari, I. Haynes, P. Liverani, C. Rosa and L-M. Shillito**

The environmental impact of political, military and religious changes in the Eastern Caelian.

**[P.3] Alvise Barbieri, M. Carvalho, P. Horta, R. Matias, D. Maio, V. Aldeias, N. Bicho and J. Cascalheira**

Tracing the primary context of Neanderthal occupations within a complex karst system – preliminary geoarchaeological results from Escoural (Alentejo, Southern Portugal).

**[P.4] Stefano Costanzo**

Archaeological landscapes and Holocene records of climate changes in the Kassala Region (Eastern Sudan): kickstart research and future perspectives.

**[P.5] Ada Dinckal, E.C. Fisher, A.I.R. Herries and C.W. Marean**

Mapping magnetism: geophysical modelling of stratigraphic features at Pinnacle Point 5-6 North, South Africa.

**[P.6] Francesca Glanville-Wallis and M. Arroyo-Kalin**

Amazonian Dark Earths: comparison based on enrichment factors and geo-accumulation indices

**[P.7] Daniela de Matos and C.E. Miller**

Site formation processes at Leba Cave, Southwest Angola.

**[P.8] Sarah Ann Meinekat, C.E. Miller and K. Rademaker**

Micro-contextual analysis of Terminal Pleistocene and Early Holocene living space and anthropogenic features in Quebrada Jaguay-280, Peru.

**[P.9] Naima Mohamed-Rodríguez, N. Mohamed-Rodríguez, A.V. Herrera-Herrera, R. Connolly, L. Leierer and C. Mallo**

Application of the QuEChERS analytical method to the analysis of real samples from a Neanderthal site.

**[P.10] Sahar Mohammadi, L. Lisá, L. Šmejda, J. Horák, P. Král, P. Goláňová, M. Hajnalová, A. Bajer, P. Moska, J. Rohovec, J. Kysela and R. Kočárová**

A pedological approach to the study of buried soils as a contribution to the climatic and human-induced erosion activity; La Terrasse, Bibracte oppidum.

**[P.11] Femke H. Reidsma, I. Sifogeorgaki, A. Ada Dinckal, H. Huisman, M. J. Sier, B. van Os and G. Dusseldorp**

Integrating geoarchaeological techniques to reveal the invisible stratigraphy at Umhlatuzana rockshelter, South Africa - a grid-based approach

**[P.12] Jordi Revelles and M. Ghilardi**

Reconstructing the Holocene palaeoenvironmental evolution of Corsican coastal wetlands based on palaeobiological proxies.



**[P.13] Wiktoria Sagan, M. Arroyo-Kalin and S. Rostain**

Raise it up and wash it all away: micromorphological and sedimentological analysis of pre-colonial raised fields from Grand Macoua and Savanna Bois Diable, French Guiana

**[P.14] Flora Schilt, V. Aldeias, J.C. Thompson, D.K. Wright and P. Kaliba**

A micro-contextual approach to pyrotechnologies of Middle and Later Stone Age foragers in central Africa. Presenting the new MicroAsh project.

**[P.15] Mara Schumacher**

Invisible floors – Investigating domestic occupation surfaces at Olynthos through micromorphology and multi-elemental geochemistry.

**[P.16] Carlos D. Simões**

The SEArch project: Investigating the 'Blue Economy' of Prehistoric Europe with microarchaeological approaches

**[P.17] Irina Vishnevskaya, A.M. Khatsenovich, N.G. Soloshenko, T.G. Okuneva, D. Bazargur, A.M. Klementiev, E.P. Rybin and J.W. Olsen**

Preliminary data on hunting strategies of Paleolithic people in central Mongolia

**[P.18] Maurizio Zambaldi, D.E. Angelucci and F. Negrino**

Stratigraphy and formation processes of the Pleistocene deposit at Balzi Rossi Museo site (Italy).

## ABSTRACTS

### Session 1

Monday 17<sup>th</sup> of May  
9 am

**[1] Conor McAdams<sup>(1)</sup>, M.W. Morley<sup>(2)</sup>, R.G. Roberts<sup>(1,3)</sup>**

(1) Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW 2522, Australia

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**New insights into the Pleistocene archaeology of mainland Southeast Asia: understanding tropical cave sediments through microstratigraphic site investigations and laboratory experiments**

*Keywords: sediment diagenesis; geochemistry; site formation processes; taphonomy; tropical*

The Pleistocene archaeological record of mainland Southeast Asia (MSEA) remains poorly understood. Uncertain chronologies and the peculiarities of the region's lithic record are compounded by the poorly constrained geomorphic and taphonomic processes that act in tropical caves. This study set out to understand the formation processes in MSEA's archaeological caves through a combination of microarchaeological case studies and laboratory experiments based on geo-ethnoarchaeological methods. Cúc Phương National Park, in North Vietnam, preserves numerous archaeological cave sites with complex sedimentary records that have frustrated previous investigative efforts. Our microstratigraphic, geochronological and geochemical analyses of the sediments at Con Moong Cave (CMC) have revealed that human occupation of that site began more than 42,000 years ago, and that episodic abandonment coincided with short-lived phases of colder, drier conditions. Questions remained, however, about sedimentary environments and assemblage taphonomy at CMC, as the mineral suites and sedimentary features that were thought to result from guano-driven diagenetic change did not conform to established models of phosphatic diagenesis in guano profiles. To address this issue, we reconstructed sedimentary palaeoenvironments under laboratory conditions, using a novel experimental approach to assess the usefulness of micromorphological features observed at CMC as environmental indicators. The experimental results confirmed our interpretations of environmental change at CMC and provided much-needed primary data related to post-depositional processes in tropical caves. Microstratigraphic studies of archaeological cave sediments have the potential to produce high-resolution records of human–environment interactions, even where sediments have been subject to extensive post-depositional change; and complementary laboratory-based experiments can constrain the relationships between micromorphological features, geochemical signals and sedimentary environments. This combination of methods could usefully be applied to sites across North Vietnam and MSEA more broadly, to better understand the processes driving Pleistocene site formation in the region and the history of cave use by people and other occupants.

**[2] Meghan McAllister<sup>(1)</sup>, M.W. Morley<sup>(1)</sup>, J.J. Tyler<sup>(2)</sup>, F.A. McInerney<sup>(2)</sup>, A.J. Blyth<sup>(3)</sup>**

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(2) Department of Earth Science, The University of Adelaide, Adelaide, South Australia

(3) School of Earth and Planetary Sciences, Curtin University, Perth, Western Australia

**Leaf waxes & lipid biomarkers: reconstructing the palaeoenvironments experienced by early H. sapiens across Southeast Asia & Australia**

*Keywords: Southeast Asia; palaeoenvironments; lipid biomarkers; savannah corridor*

Current understandings of local environmental conditions that early H. sapiens encountered when they first arrived into Southeast Asia (Sunda) and Australia (Sahul) between Marine Isotope Stages (MIS) 5-2 (124-11.7 ka), is incredibly sparse. In this talk I will discuss my doctoral research; the potential of developing a high-resolution, quantitative palaeoenvironmental proxy in and around the local environments of archaeological cave sites through the extraction and analyses of leaf wax lipid biomarkers (n-alkanes). Reconstructing local site environments across Sunda and Sahul is imperative for the advancement of Southeast Asian (SEA) and Australian Pleistocene geoarchaeology, contributing to an improved comprehension of past human-environment relations. Moreover, research findings will contribute to better understand the current debate surrounding the possible existence and extent of a savannah corridor through mainland and island SEA. Improving our understanding of how early H. sapiens adapted to a landscape subject to significant sea level immersions and regressions can assist in addressing present uncertainties surrounding adapting to a future of sea level rise. Given the hot and humid conditions of the tropics causing degradation of valuable archaeological material, leaf wax n-alkanes have been selected due to their resilience against degradation and have been recorded in the geological record for several million years. Expected results will form rare and valuable quantitative palaeovegetation reconstructions generated from the study of archaeological sediments from a range of sites in Southeast Asia and Australia. This will allow for cross-site comparison to establish differing spatial vegetation and environment conditions. Alongside additional geoarchaeological investigations to refine site occupational history, it should be possible to further elucidate the influence of environmental conditions on early H. sapiens migration and settlement patterns.

**[3] Natasha Nagle<sup>(1)</sup>**

(1) Department of Archaeology, Flinders University, Adelaide, Australia

**Sediment fingerprinting: identifying sedimentological characteristics and formation processes at Late Pleistocene archaeological sites in Southeast Asia and Australia**

*Keywords: sediment fingerprinting; paleoenvironment; Late Pleistocene; hominin dispersal; Southeast Asia*

Sediment fingerprinting utilizes a combination of Earth Science-based techniques, including chemical characterization, mineralogical identification, morphological analysis, and geomorphological survey, to identify specific characteristics of—and reconstruct processes related to—the sourcing, deposition, and subsequent alteration of sediments related to past environmental changes. Utilized widely in the environmental sciences, sediment fingerprinting has been shown to be useful in geoarchaeological research, but wider exploration of this technique as applied to archaeological questions, particularly in humid tropical climates, has yet to be conducted. My doctoral research seeks

to use sediment fingerprinting to generate unique identifiers for sediments found at different key Late Pleistocene (c. 127 - 12 kya) archaeological sites in Southeast Asia and Australia to begin answering questions regarding the types of environments favored by early waves of *Homo sapiens* moving into the region - specifically identifying how landscape change affects the way archaeological sediments are delivered and deposited. This can provide a robust reconstruction of the local Late Pleistocene landscapes these hominins would have interacted with - thereby placing our ancestors back into their associated environmental contexts and, in turn, better equipping us to interpret past human behavior.

**[4] Vito Hernandez<sup>(1)</sup>, M.W. Morley<sup>(1)</sup>, P. Durringer<sup>(2)</sup>, J-L. Ponche<sup>(2)</sup>, K. Westaway<sup>(3)</sup>, A-M. Bacon<sup>(4)</sup>, L. Shackleford<sup>(5)</sup>, V. Souksavady<sup>(6)</sup>, F. Demeter<sup>(7)</sup>**

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(6) Department of Heritage, Ministry of Information, Culture and Tourism, Lao Democratic People's Republic

(7) Lundbeck Foundation GeoGenetics Centre, Globe Institute, University of Copenhagen, 1350 Copenhagen, Denmark

### **Early Human Occupation of Tam Pa Ling, Laos: Preliminary Microstratigraphic Results**

*Keywords: microstratigraphy; micromorphology; Homo sapiens; Laos; Southeast Asia*

The Cave of Monkeys (Tam Pa Ling) in north-eastern Laos has yielded the earliest *Homo sapiens* fossils from continental Southeast Asia (Demeter 2012). Their presence in the area ~64-46 ka supports an early wave dispersal of modern humans out of Africa, eastwards into Southeast Asia and beyond. Despite the key role of the cave site in helping us understand the nature and timing of modern human movements into the region, no artefacts or occupation horizons have been identified during the excavation of the fossil-bearing layers. To aid the contextualization of the skeletal remains a program of microstratigraphic (micromorphological) analyses was initiated, which forms a component of a doctoral research program that is investigating some of the oldest fossil sites in Southeast Asia and Australia. Five intact blocks from Tam Pa Ling's stratigraphic sequence dating from MIS 3 (~57 ka) to the Terminal Pleistocene (~12 ka) were prepared for thin-section analysis. Preliminary results reveal distinct changes in sediment depositional environment, and human activity is confirmed throughout the cave sequence via microarchaeological evidence. Combustion byproducts and possible hearth features comprise most of the evidence so far identified. Further analysis of the microstratigraphy complemented by other geoarchaeological analyses will better elucidate the Tam Pa Ling sequence as a key early human occupation site in continental Southeast Asia.

## Session 2

Monday 17<sup>th</sup> of May  
10 am

### [5] Xiaolin Ren<sup>(1)</sup>, D. Mo<sup>(2)</sup>, M.J. Storozum<sup>(3)</sup>

(1) Institute for the History of Natural Sciences, Chinese Academy of Sciences, China

(2) College of Urban and Environmental Sciences, Peking University, China

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#### **Climate change, landscape evolution and settlement distribution patterns in the Shuangji River valley, Central China, since the Upper Paleolithic**

*Keywords: human–environment interactions; Shuangji River valley; landscape evolution; climate change; settlement distribution patterns*

The past decades have seen an upsurge in the paleoenvironmental studies of Chinese archaeological sites. However, systematic investigations on human-environment interactions in river valleys are still rare in Central China and thus require further study. Here, we reconstruct the landscape evolution and its relationship with climate change and settlement distribution patterns in Shuangji River valley since the Upper Paleolithic. From 45 ka BP to terminal Paleolithic, under a cold climate condition, a thickness of ~20 m fluvial-lacustrine sediments and loess-derived alluvium deposited in the middle reaches of river valley. There was a transition from fluvial-lacustrine deposits to aeolian deposits around 28 ka BP, along with the deposition rate decreasing. Three stages of fluvial terraces were formed since the Upper Paleolithic. The formation of the third terrace (T3) was dated between 20 and 10 ka BP, and provided ideal habitat for last hunter-gatherers and early farmers through the terminal Paleolithic to early Neolithic. From 8 to 4 ka BP, the river valley aggraded during a warm and humid climate condition, while the second terrace (T2) was formed slowly. Due to its suitability for human habitation, settlements gradually moved downstream and collected onto the alluvial valleys, associated with the change of subsistence strategy. After 4 ka BP, the climate aridity coincided with large-scale river downcutting processes which led to the disappearance of lakes and swamps. This paralleled the emergence of urban settlements. The late Holocene valley incision and smaller-scale first terrace (T1) shaped the present landscape in the historical period. Our results contribute to a better understanding of the relationships between climate change, landscape evolution and human settlement patterns in the cradle of Chinese civilization.

### [6] Aristeides Varis<sup>(1, 2)</sup>, C.E. Miller<sup>(3)</sup>, P. Cuthbertson<sup>(1)</sup>, A. Namen<sup>(1, 4)</sup>, Z. Taimagambetov<sup>(5)</sup>, R. Iovita<sup>(1, 6)</sup>

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#### **Micromorphology in a survey context: insights from cave survey in South Kazakhstan**

*Keywords: geoarchaeology; micromorphology; survey; Central Asia; caves*

Central Asia has a great potential for human evolution research in the Late Pleistocene. Human remains and cultural assemblages found in caves support the presence of at least three overlapping hominin metapopulations: the Denisovans, the Neanderthals, and modern humans. However, although rich, the known cave record is limited since only a few caves in Central Asia exhibit Palaeolithic occupation. Until now, no previous research has tried to systematically evaluate the frequency of Palaeolithic cave occupation or the formation processes that constitute the cave record in semi-arid Central Asia. To address this deficiency, the Palaeosilkroad team recently conducted systematic survey and test excavations in the piedmonts and foothills of South Kazakhstan, primarily targeting caves. Logistical constraints on time in the field, as well as transport and storage during long survey campaigns, limited our ability to apply an exhaustive range of analytical techniques. Under these circumstances, we chose to use micromorphology as our primary analytical tool because of the plethora of contextual information that it can provide. Here we present our preliminary survey and micromorphology results focusing on selected sites in the Qaratau mountains of South Kazakhstan. Sediment cover varies among the surveyed caves and loess-like sediments dominate the cave sequences. Despite the frequent reworking, good organic preservation and limited diagenesis indicate that the Qaratau caves have good preservation potential. Deposits of potentially Pleistocene age are scarce, but we plan to address this with further systematic excavation and dating work in the future. Our study provides new data in the geoarchaeologically neglected region of Central Asia and demonstrates that micromorphology has great analytical potential even within the limitations of rigorous survey projects. We outline some of the processes that influence the formation and preservation of cave sediments in the region, as well as broader implications for other semi-arid environments.

**[7]**    **Natàlia Égüez**<sup>(1)</sup>, M. Jambrina-Enríquez<sup>(1)</sup>, O. Seitsonen<sup>(2)</sup>, L.G. Broderick<sup>(3)</sup>, J. Bayarshaikhan<sup>(4)</sup>, J-L. Houle<sup>(5)</sup>

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#### **Application of compound specific stable isotope analysis in sediments for tracing environmental changes. A 4000 BP multiperiod habitation site in the Züünkhangaï region (Mongolia)**

*Keywords: alkanes; stable isotope analysis; palaeoenvironment; pastoralism; Mongolia*

At present, the development of mobile pastoralism and precise chronology and nature of early semi-nomadic pastoralist societies in Mongolia is known almost exclusively from funerary contexts. Here we present the results of the ongoing Western Mongolia Archaeology Project geoarchaeological work, carried out at an open-air stratified habitation site in the Züünkhangaï region. Radiocarbon dates from the sedimentary deposit cover a continuous and consistent occupation of the site for the last four millennia. Compound specific  $\delta^{13}\text{C}$  and  $\delta^2\text{H}$  of individual n-alkanes, which record both ecologic (carbon isotope) and hydrologic (hydrogen isotope) information in combination with n-alkanes ratios, are presented here for terrestrial palaeoenvironmental reconstruction. Results show that people occupied the site repeatedly during the winter season. Moreover, intensity of occupation occurs during warm winters in three specific moments: during Middle Bronze age, Late Iron age (Xiongnu

period), and around 940 cal AD when the Silk Road networks are well consolidated. Our molecular approach contributes to key debates about climate change and pastoralism development in Central Asia.

**[8] Yashaswini Jayadevaiah<sup>(1)</sup>, U. Misra<sup>(2)</sup>, A.K. Basantray<sup>(2)</sup>, C. Athul<sup>(2)</sup>, A. Mandal<sup>(2)</sup>, K. Patil<sup>(1)</sup>**

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### **Preliminary findings of the micro-gravity study at Śringaverapura, India: a 2000-year-old water harvesting tank system**

*Keywords: micro-gravity study; Śringaverapura; ancient water harvesting tank system; geo-explorations*

The archaeological site at Śringaverapura, India was excavated during the 1970s and 80s. An interconnected tank system of 230 m length was discovered. It was concluded as floodwater harvesting-storage system with three tanks (i.e., tank A, B and C) belonging to 100 BC. Owing to funding limitations and stratigraphic overlapping of later periods, the whole tank area was not excavated. The understanding of the tank shape and its structural members was concluded based on horizontal excavations at certain parts and restricted vertical excavations at other, like along the length of the tank. Therefore, the existence of unknown structural members in the tank is an admissible prospect. Considering this, micro-gravity and real-time kinematic GPS surveys were conducted over the unexcavated and accessible portions of the study area. A total of ~330 data points were measured along different profiles with an objective to delineate the subsurface continuity of the unknown buried walls of the tanks.

Calculated Bouguer anomaly (BA) map has revealed some high anomaly linear trends that are further enhanced in the first vertical derivative map. High anomaly linear trend in the region between Tank A & B and in Tank C indicates the subsurface continuation of high-density material possibly due to buried walls. In the unexcavated part of Tank B, a high to low transition in BA map indicates the absence of high-density material beyond the high anomaly region. However, the first vertical derivative map has effectively delineated the linear high anomaly trend that can be inferred as high-density material of the brick walls. Thus, the analysis indicates the continuation of high-density material in subsurface suggestive of hitherto unknown structural parts. However, considering the stratigraphic overlapping further analysis of the data is suggested to understand the vertical depth of the anomalies to corroborate them with different stratigraphic layers to conclude the finds.

## Session 3

Monday 17<sup>th</sup> of May  
11 am

[9] **Sally Hoare**<sup>(1)</sup>, R.M. Albert<sup>(2)</sup>, I.G. Stanistreet<sup>(3, 6)</sup>, H. Stollhofen<sup>(4)</sup>, S.M. Rucina<sup>(5)</sup>, J.A.J. Gowlett<sup>(1)</sup>

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### **New archaeological sites from Kilombe Caldera, Kenya: site formation and palaeoenvironmental context of hominin occupation in a highland setting**

*Keywords: site formation; palaeoenvironments; Oldowan; Acheulean; Volcanic Highlands*

Records of early hominin activity in highland settings are unusual. Volcanoes and volcanic highlands are areas of predominant erosion, so records of human habitation are unlikely to have been preserved (Hoare et al. 2021; Hovers et al. 2021). Kilombe Mountain however preserves an exciting new record of early hominin activity, Oldowan and Acheulean technologies, at a strikingly high-altitude setting in rugged mountain terrain (Hoare et al. 2021). There, erosional downcutting has exposed a succession of interleaved tuffs and sedimentary rocks of the intra-caldera fill, also preserving tool and bone assemblages centred on the volcanic peak. This paper examines the sedimentary and palaeoenvironmental contexts for hominin occupation at Kilombe using geochemical and microbiological analyses of bulk sediment samples, hand-drilled from lacustrine units in the caldera fill.

Quaternary lacustrine sequences from East Africa are important archives of orbitally forced palaeoclimatic changes, which affects lake-level limit and palaeovegetation, and which have been proposed to control hominin occupation of and evolution within East Africa. Here we investigate in detail a well preserved and fairly continuous lake sedimentary sequence from Kilombe Volcano, whose caldera-fill also preserves traces of hominin activity at several localities, the lower involving Oldowan and higher Acheulean technologies. Microbiological analyses include the identification of various siliceous microremains preserved in the sediments such as phytoliths, diatoms and sponge spicules. Changes in chemical weathering intensity are examined using a multi-proxy approach including geochemistry, Fe-oxide mineralogy and Total Organic Carbon. The identification of phytoliths, diatoms and sponge spicules record vegetation presence and environmental conditions (lake regressions and transgressions) that vary through time. The magnetic and geochemical properties of the clays document from incipient through to intense changes in catchment weathering. Combined, the results record palaeoclimatic and palaeoenvironmental change during the Quaternary, thus providing a context for hominin occupation in a highland setting.



**[10] Michael B. Toffolo<sup>(1)</sup>**

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**Geoarchaeology of Pleistocene open-air sites in the central interior of South Africa**

*Keywords: South Africa; Pleistocene; alluvial; wetland; landscape*

The interpretation of the archaeological record at prehistoric sites depends primarily on its degree of preservation. In this regard, caves and rock shelters may offer long sequences of relatively undisturbed deposits including preserved artifacts and sedimentary matrix. However, sheltered sites are not always available in a given region and archaeological information must be retrieved from open-air sites. The latter are located within active sedimentary systems that may significantly alter or obliterate traces of past occupations through the action of wind and water, in the form of deposition and erosion of sediments. In addition, open-air sites are often the product of ephemeral hunter-gatherer activities that do not leave much to preserve in the first place. Therefore, a thorough geoarchaeological approach going from landforms to the level of molecules in sediments and bones is required in order to characterize the depositional and taphonomic contexts of human occupations across the landscape, and to provide a robust framework for paleoenvironmental proxies and absolute dating methods. This becomes especially apparent in the central interior of South Africa, which lacks caves and features a mosaic of grasslands and shrublands dissected by sporadic rivers and punctuated by springs and playa lakes. These wetlands sustained hominins and modern humans throughout the Pleistocene, and at the same time are characterized by long stratigraphic sequences that offer a privileged view into past environments. Using case studies from the Free State Province of South Africa, I aim at showing how the integration of macro- and micro-scale datasets, combined with accurate age determinations, can improve the reconstruction of site-formation processes and paleoenvironments at alluvial and spring sites in the region, as well as the interpretation of their archaeological record.

**[11] Kristen Wroth<sup>(1)</sup>, B. Bousman<sup>(2)</sup>, C. Tribolo<sup>(3)</sup>, L. Rossouw<sup>(4)</sup>, C.E. Miller<sup>(1)</sup>, M.B. Toffolo<sup>(3)</sup>**

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**Micromorphology and phytolith analysis from the Middle-to-Later Stone Age site of Lovedale, Free State, South Africa**

*Keywords: micromorphology; phytoliths; open-air; paleoenvironment*

Much of our understanding of early modern human behavior in South Africa stems from the analysis of archaeological sites located in caves and rock shelters. These sites present an important picture of foraging strategies and behaviors in resource-rich, often coastal environments. However, there is increasing evidence for hominin exploitation of open-air sites throughout South Africa, such as in the grasslands of the interior. These sites are often more difficult to find and interpret due to a variety of preservation concerns and a dynamic, erosional landscape. Geoarchaeological and

microarchaeological techniques such as sedimentology, micromorphology, and phytolith analysis are key to understanding how open-air sites formed and changed through time. This paper presents the preliminary results of twelve micromorphological samples collected from the open-air site of Lovedale, located in the Free State near Bloemfontein. The analysis of these samples provides an understanding of the formation processes of the site, showing shifts in the depositional environment as the course of the local river changed and the area alternated between wetter and drier conditions during marine isotope stages (MIS) 5-3. The micromorphological analysis also provides a framework for interpreting the phytolith and FTIR analyses carried out on bulk sediment samples taken from the same area as the micromorphological blocks. Grass phytoliths dominate the plant microremain assemblage and provide a highly resolved picture of vacillations between warmer and wetter and cooler and drier periods. Together, these analyses provide a more holistic picture of the paleoenvironment, allowing for a better understanding of the landscape through which early humans moved and the resources that would have been available to them.

**[12] Aviad Agam<sup>(1)</sup>, T. Rosenberg-Yefet<sup>(1)</sup>, L. Wilson<sup>(2)</sup>, M. Shemer<sup>(3, 4)</sup>, R. Barkai<sup>(1)</sup>**

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### **Flint type analysis from Late Acheulian Jaljulia (Israel), and possible implications for the origins of the Levallois method**

*Keywords: flint, Levallois, Acheulian, Levant, Lower Paleolithic*

The Levallois method, often considered a hallmark of the Middle Paleolithic Mousterian, has been recently observed in Lower Paleolithic Acheulian sites, indicating its earlier origin, although the circumstances leading to its emergence are still debated. We aim at contributing towards this debate, studying patterns of flint procurement and exploitation at the Late Acheulian site Jaljulia (Israel; ~500-300 kya). We classified artifacts into flint types, using four samples: a general sample (n=407 including all categories); bifaces (n=60); "regular" cores, with one/two striking platforms (n=43); and Levallois-related cores: prepared (n=110), proto-Levallois (n=62) and discoidal cores (n=40). A geologic survey located potential flint sources, and a petrographic analysis was used to assign flint types to sources. Local Turonian flint of the Bi'na Formation forms 66.8% of the general sample. Selectivity in exploitation of specific flint types was observed, including among local materials. Brecciated flint types are the most common in the general sample (31.2%), but are more common among handaxes (60.0%) and discoidal cores (69.2%). Brecciated flint types are found in large packages, and are associated with the production of durable artifacts, proposing two possible considerations for this preference. Among proto-Levallois and prepared cores, while brecciated flint types are frequent, fine-textured homogenous flint types are more common, suggesting that such flint types are better-suited when improved control over the end-product is needed. The results indicate an understanding of the different flint traits and the suitability of specific flint types for specific artifacts manufacturing.

Concerning the Levallois method, we propose a link between the desired end-product, the degree of accuracy needed, the wanted size, and the selected flint types. Inferring the considerations affecting these choices may help understand the benefits of the Levallois technology, contributing to our understanding of the origins of the Levallois method, one of the major technological transformations occurring during Paleolithic times.

## Session 4

Monday 17<sup>th</sup> of May  
2 pm

### [13] Alyssa Victoria Pietraszek<sup>(1)</sup>, Y. Zaidner<sup>(2)</sup>, R. Shahack-Gross<sup>(1)</sup>

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#### **Use of fire and space at Unit V of the Middle Paleolithic open-air site at Nesher Ramla, Israel**

*Keywords: ash; Middle Paleolithic; Nesher Ramla; spatial distribution; hominin behavior*

Despite abundant evidence for the use of fire at cave sites, weaker signs of its use have been identified at open-air sites. This discrepancy has brought into question the preservation potential of more inconspicuous fire residues at these types of sites or whether they are present at all. A recently discovered site near Ramla, Israel may help to fill part of this gap by providing for the first time clear evidence for combustion activities at an open-air site. The remains of an *in situ* hearth and an ash midden were identified at the Middle Paleolithic site of Nesher Ramla along with abundant evidence for *in situ* human activities. The study presented here aims to assess the use of fire and fire-related behaviors from the richest unit, Unit V, at Nesher Ramla by identifying signs of spatial partitioning in combustion-related activities. The distributions of microscopic fire remains and macroscopic findings revealed a consistent presence of burned bones and ash pseudomorphs across the habitation surface, with slightly higher concentrations of ash obtained from the eastern part of Unit V. However, the relatively low quantities of ash suggest a short-term occupation, their partial preservation, or dilution during sampling. Nonetheless, fire-related behaviors can still be reconstructed. The vast distribution of fire remains across the habitation surface suggests the reworking of ash, possibly intentionally by the site's inhabitants, while the higher concentrations of pseudomorphs in the eastern part of Unit V likely signal an area where the ash originated from or was transported to. These results help to shed light on the degree of intentionality in the maintenance of combustion features and spatial partitioning at open-air sites, and suggest that the previously limited evidence of fire-related activities at open-air sites is likely an issue of preservation.

### [14] Lucy Wilson<sup>(1)</sup>

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#### **Seasonal territory use in the Middle Palaeolithic of the Vaucluse, southern France.**

*Keywords: Middle Palaeolithic; lithic landscape; territory; seasonality; Bau de l'Aubesier*

Combining data from the season of death of fauna, environmental data from micromorphological analyses, and territorial data based on sources of raw material in lithic assemblages shows that within a single 1-m thick layer of the Bau de l'Aubesier (Middle Palaeolithic, in the Vaucluse, France), we can distinguish different strategies of use of the territory in different seasons of the year. To be clear: this does not mean different strategies in different seasons of a single year – our time scale is not that finely defined! However, within layer H at the Bau de l'Aubesier, the

lowest and highest sections correlate with summer use during a cold climate, while the middle section seems to have formed during the winter of a warmer climate period. The lithic assemblage of that middle section shows a greater emphasis on raw material sources which are both closer and easier to get to – thus avoiding difficult travel – than in the other sections. The faunal species also seem to bear out this idea of winter occupation correlating with a restricted territory, and a territorial centre of gravity that is shifted towards the site, compared to the territory used in other parts of layer H, and in other layers of the Bau.

**[15] Javier Davara<sup>(1)</sup>, A.V. Herrera-Herrera<sup>(1)</sup>, M. Jambrina-Enríquez<sup>(1, 2)</sup>, C.M. Hernández<sup>(3)</sup>, B. Galván<sup>(4)</sup>, C. Mallo<sup>(1,4,5)</sup>**

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#### **Lipid biomarker analysis of contextualized lithic remains from El Salt Middle Palaeolithic site (Alicante, Spain)**

*Keywords: lipid biomarkers; lithics; sediment; Middle Palaeolithic; GC-MS*

The analysis of lipid biomarkers preserved in archaeological materials and sediments has yielded a large amount of valuable data about past human populations. However, lithic objects, the most ubiquitous remains of Palaeolithic/African Stone Age sites, have not yet been extensively studied through this analytical approach. Important issues such as the lipid retention potential in archaeological lithics, as well as the effects of post-depositional lipid migration from sediment to objects remain unaddressed. In this study, we extracted lipid biomarkers –n-alkanes, alcohols, and fatty acids– preserved in flint flakes and limestone pebbles from El Salt Middle Palaeolithic site (Alicante, Spain) and analysed them using gas chromatography-mass spectrometry (GC-MS). The lipid composition of the sediment surrounding each of the lithic objects was also analysed for comparison. Preliminary results suggest that the lithic remains preserve lipid biomarkers, and that these are different from those present in the sediment around them. Lithic objects also yielded smaller amounts of lipids than the sediment samples. These results highlight the preservation potential of the biomolecular Palaeolithic record and the importance of exploring it in different contexts, both in sediments and in other kinds of material record.

**[16] Lucia Leierer<sup>(1, 2)</sup>, Á. Carrancho Alonso<sup>(3)</sup>, L. Pérez<sup>(4, 5)</sup>, Á. Herrejón Lagunilla<sup>(6)</sup>, A.V. Herrera-Herrera<sup>(1)</sup>, R. Connolly<sup>(1, 2)</sup>, M. Jambrina-Enríquez<sup>(1, 7)</sup>, C.M. Hernández Gómez<sup>(2, 8)</sup>, B. Galván<sup>(2)</sup>, C. Mallo<sup>(1, 2)</sup>**

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### **It's getting hot in here – microcontextual study of a potential pit hearth at the Middle Paleolithic site of El Salt, Spain**

*Keywords: Middle Paleolithic; micromorphology; lipid biomarker analysis; pit fire*

By studying combustion structures, which conceal information about anthropogenic activity, we might learn about their makers. This is especially important for remote time periods like the Middle Paleolithic, whose archaeological record comprises numerous combustion structures. The majority of these are simple, flat, open hearths, although a small number of features situated in pit-like depressions have been recorded. Given that combustion structures built on a flat surface can result in pit-like color alteration of the underlying sediment, accurate identification of pit hearths is a crucial step prior to behavioral interpretation. Here we present a comprehensive study of a possible pit hearth from the Middle Paleolithic site of El Salt, Spain, using a microcontextual approach combining micromorphology, lipid biomarker analysis, archaeomagnetism, and zooarchaeology. This pit hearth involves a true depression containing a thick plant ash deposit. It reached very high temperatures, possibly multiple burning events, and long combustion times. Morphologically distinct combustion structures in a single archaeological context may indicate different functions and thus a diverse fire technology, pointing to Neanderthal behavioral variability.

## Session 5

Monday 17<sup>th</sup> of May  
3 pm

**[17] Martin Arriolabengoa<sup>(1)</sup>, J. Ríos-Garaizar<sup>(2)</sup>, J. Aranbarri<sup>(3)</sup>, A. Arranz-Otaegui<sup>(4)</sup>, M.A. Medina-Alcaide<sup>(5)</sup>, I. Intxaurbe<sup>(1)</sup>, O. Rivero<sup>(6)</sup>, D. Garate<sup>(7)</sup>**

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### **Final MIS 3 to early MIS 1 sedimentary sequence from Atxurra archaeological site (northern Iberian Peninsula): An approach from micromorphological and mineralogical analysis**

*Keywords: unconsolidated sediment petrology; cave processes; hearths; Magdalenian*

Atxurra cave (Berriatua, northern Iberian Peninsula) has recently become one of the most relevant Magdalenian archaeological complexes in the Cantabrian Region, due to the discovery of a unique assemblage of rock art and an ephemeral occupation in the lower cave level. With the aim of understanding the palaeoenvironmental conditions and the nature of the human occupation, a multi-proxy analysis was carried out in the archaeological site situated in the entrance of the cave. In this work we present the micromorphological and mineralogical data carried out in five undisturbed sediment thin sections and 12 sediment samples analysed by X-ray diffraction (XRD). The samples belong to a sedimentary sequence dated by radiocarbon from the end of Marine Isotopic Stage (MIS) 3 to the early MIS 1.

The results highlight that hyper-concentrated runoff flows from the outside of the cave were the predominant sedimentary processes across the occupation. But the sedimentary processes were not continuous as a depositional hiatus was identified during the Last Glacial Maximum. In addition, the results indicate that the sequence did not include reworked sediments from older deposits or different origins, which secures the interpretation of other proxies such as palynology, anthracology, microfauna, lithic technology, etc. On the other hand, we have identified anthropogenic fire use in all the stratigraphic layers, most of them related to hearths, meaning that the cave was used as shelter in different moments of the Upper Palaeolithic (Early Gravettian, Lower and Upper Magdalenian). More specifically, we have identified at least three *in situ* hearths that maintain their microstructure intact. The oldest of these three hearths shows cave pearl accumulations that have been placed there by humans. The second corresponded to a shallow hearth. And in the third hearth, we document the first record of shells (e.g. molluscs, eggshells and/or gastropods) in Atxurra cave.

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### **Geoarchaeological investigation of the Middle to Upper Paleolithic anthropogenic features in Fumane Cave (Italy)**

*Keywords: micromorphology; combustion features; Middle Paleolithic; Upper Paleolithic; living space*

Monti Lessini, in the northeast of Italy, is considered a key region for the investigation of the behavior of hunter-gatherer groups. The region contains several archaeological sites that contribute to the reconstruction of the archaeological record during the Late Pleistocene. Fumane Cave is one of the richer deposits in the area, with 12m of stratified deposits. The study presented here provides a diachronic analysis of anthropogenic features from Fumane Cave, using a range of geoarchaeological tools (i.e. micromorphology, FTIR analysis, and micro-XRF) in order to better understand human actions and their interaction within the living space. The results include evidence for direct and indirect features, combustion features, human reworking, spatial organization, long term vs short term events, and post-depositional processes, thereby providing a broad view of occupational strategies employed by the site's inhabitants. The analysis provides new data on the arrangement and maintenance of the living space inside the cave and demonstrates the potential of microcontextual techniques for understanding traces of human activity within an archaeological site.

**[19] Andrea Zerboni<sup>(1)</sup>, E.E. Spinapolice<sup>(2)</sup>, M.C. Meyer<sup>(3)</sup>, S. Talamo<sup>(4, 5)</sup>, G.S. Mariani<sup>(6)</sup>, L.A. Gliganic<sup>(3)</sup>, L. Buti<sup>(7)</sup>, M. Fusco<sup>(2)</sup>, M.P. Maiorano<sup>(8)</sup>, S. Silvestrini<sup>(7)</sup>, R. Sorrentino<sup>(7, 9)</sup>, A. Vazzana<sup>(7)</sup>, M. Romandini<sup>(7)</sup>, A. Fiorini<sup>(8)</sup>, A. Curci<sup>(8)</sup>, S. Benazzi<sup>(7)</sup>**

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(8) Università di Bologna, Dipartimento di Storia Culture Civiltà, Bologna, Italy

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### **Site-forming processes and age of the Mid-Upper Palaeolithic sequence at Uluzzo C Rock Shelter (Apulia, Southern Italy)**

*Keywords: cave sediments; micromorphology; optically stimulated luminescence; Uluzzo C; Italy*

The demise of Neanderthals and the dispersal of *Homo sapiens* in Eurasia is a hot topic in archaeological and anthropological research. In Italy, such transition is related to the Uluzzian technocomplex, which also corresponds to the first archaeological evidence for *H. sapiens* along the European continent. The Uluzzo C Rock Shelter in southern Italy is one of the key sites to explore this event. Fresh geoarchaeological investigation at the site allowed to reconstruct the timing and the main depositional and post-depositional processes in charge of the formation of the archaeological record. Optically Stimulated Luminescence (OSL) ages from Uluzzo C Rock Shelter provides a terminus post quem for the end of the Mousterian in the region, constraining the disappearance of the Neanderthals in that part of Italy to  $\geq 46 \pm 4$  ka. Moreover, our OSL chronology confirms the onset for the Uluzzian in



the area to ~39.2–42.0 ka; this age is congruent with radiocarbon dating results and tephrochronology from neighbouring archaeological sites. Sedimentological analyses and thin section micromorphology suggest that a range of depositional processes occurred between MIS4–2. Most sediments are related to the dismantling of the vault of the rock shelter and wind input of loess deflated by the continental shelf that was subaerial exposed during glacial times. The occasional reactivation of the hydrology of the local karst system under more humid conditions further contributed to the formation of specific layers consisting of accumulations of former Terra Rossa-type soil fragments. Superposed to sedimentary processes, several post-depositional processes modified the deposits; among them, strong bioturbation and the mobilization and recrystallization of calcite. Excavation at Uluzzo C Rock Shelter has been founded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 724046 – SUCCESS; <http://www.erc-success.eu/>).

## Session 6

Tuesday 18<sup>th</sup> of May  
9 am

**[20] Isaac Ogloblin Ramirez<sup>(1)</sup>, E. Galili<sup>(2,3)</sup>, R. Shahack-Gross<sup>(1,3)</sup>**

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### **Underwater micromorphology: A case study of combustion features from the submerged Neolithic sites of the Carmel Coast, Israel.**

**Keywords:** *micromorphology; combustion features; Neolithic; underwater archaeology*

The Neolithic of the southern Levant was a period of pyro-technological innovation. While research on products such as lime plaster and pottery was conducted, combustion features from this period have rarely been studied, partly because of paucity of clearly preserved such features. Following a recent identification of well-preserved heated mud brick concentrations at two submerged Neolithic settlements off the Carmel coast - Pre-Pottery Neolithic C Atlit-Yam and Late Pottery Neolithic Neve Yam – we present here a study of the underwater features associated with these concentrations. Key questions involve the potential of preservation of micro-geoarchaeological signals for heat, such as infrared spectra of clay minerals and presence of wood ash pseudomorphs, at sites that have been inundated under marine conditions for 6000-9000 years. Our results indicate the presence of fire remains inside the mud brick concentrations. Moreover, the data suggests different use of fuel resources in the two settlements that may be related to changes in socio-economic activities.

**[21] Jos Kleijne<sup>(1)</sup>**

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### **MicroTRASH: first microscopic insights into Later Neolithic Northern European midden practices**

**Keywords:** *middens; micromorphology; Neolithic*

In January 2021, the MSCA-IF project MicroTRASH started. In this project we are using archaeological soil micromorphology and lipid biochemistry to understand the practices of waste deposition on midden sites along the North Sea and Baltic coasts. Our particular attention focuses on Later Neolithic (3200-2000 BC) middens. During this period, large scale social, cultural, economic, and genetic transformations take place across Europe. It is still largely unclear in what way coastal communities adapted their lifeways to these changes. In order to shed light on this, the deposition of waste from ubiquitous hunting/gathering activities and early agricultural practices is studied. First results indicate alternating episodes of dumping domestic waste and burning organic 'bedding' material. These practices take place all over coastal Northern Europe in lacustrine, marine, and freshwater environments.

**[22] Rachel Kulick<sup>(1)</sup>, D. Lewis<sup>(2)</sup>, C. Atkins<sup>(3)</sup>, F. Berna<sup>(4)</sup>, K. Fisher<sup>(5)</sup>, C. Kearns<sup>(6)</sup>, S. Manning<sup>(7)</sup>**

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**Geoarchaeology at Bronze Age Maroni Vournes, Cyprus: Micromorphology and Palaeolandscape Analysis**

*Keywords: micromorphology; palaeolandscape; Bronze Age; urbanism; Cyprus*

Geoarchaeological research conducted in 2019-2021 as part of the Kalavassos and Maroni Built Environments (KAMBE) project focused on collecting multiscalar and high-resolution geoarchaeological data from the Late Bronze Age city of Maroni Vournes in south-central Cyprus. The aim of the geoarchaeological project is to determine the uses of space in and around the site's structures and activity areas as well as to connect site formation processes with social activities and environmental transformations occurring in the surrounding landscape. This paper discusses the results from two key aspects of this geoarchaeological research: (1) the thin section micromorphological analyses of samples from around a monumental Late Cypriot wall and (2) the investigation of palaeolandscape features surrounding the site via Sentinel-2 satellite spectral imagery data. The results – including the observation of palaeochannel deposits beneath parts of the site – demonstrate how multiscalar, high-resolution geoarchaeological and environmental data, examined in conjunction with archaeological contexts revealed by ongoing and previous excavations, can contribute to understanding the structure and transformation of this major regional site in its broader socio-environmental landscape.

**[23] Federico Polisca<sup>(1)</sup>, C. Nicosia<sup>(1)</sup>, C.E. Miller<sup>(2)</sup>, B. Ligouis<sup>(2)</sup>, F. Gonzato<sup>(3)</sup>, C. Mangani<sup>(4)</sup>**

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**Geoarchaeology of daily life: insights on Bronze Age lifeways from the waterlogged site of Oppeano 4D (Verona, Italy)**

*Keywords: geoarchaeology; micromorphology; waterlogged; household archaeology; Bronze Age*

Waterlogged sites have always to deal with problems in identifying domestic accumulations in primary position, since difficultly pile-dwellings preserve the raised floors on which the inhabitants lived. A unique scenario in the European Bronze Age framework is thus represented by the recently discovered site of Oppeano “4D” (Verona, Italy). Here, eight huts built on (then) dry ground preserved in a pristine state because of a rapid burial and waterlogged conditions soon after the site abandonment. Wooden posts, boards, and wattle and daub walls allowed to perfectly discern the limits of each house, distinguishing the internal stratification with multi-phase fireplaces alongside to finely laminated occupation deposits resulting from everyday domestic life.

Geoarchaeological methods were applied to reconstruct the inhabitants' daily practices from the sedimentary deposit that characterized the better-preserved hut of the settlement. In detail, micromorphology, supported by chemical data and organic petrology, allowed to link the characteristics of the sub-units distinguished in the sequence to single behaviours or to a palimpsest of activities.

Domestic combustion activities represented the main accruing factor, as testified by finely laminated ash levels. These resulted from the hearth maintenance and the subsequent spreading of combustion residues on the floor probably to absorb humidity and to sanitise. Wood resources, that should have been abundant in the area, were used as primary combustible, with few evidences of grasses and chaff. Ash layers were interspersed with stalling deposits mainly composed by trampled herbivore dung mixed with minor amounts of burning charcoals and ashes. Furthermore, organic petrology identified traces of *in situ* tar production, that may be related to breeding practices. Geoarchaeology thus allowed to interpret the hut as a multifunctional space, where: (1) the sedimentation reflected the different uses of the house, and (2) humans and animals lived together at least in some moments of the year (i.e. byre-dwelling).

## Session 7

Tuesday 18<sup>th</sup> of May  
10 am

**[24] Guido Stefano Mariani<sup>(1)</sup>, F. Brandolini<sup>(2)</sup>, S. Naitza<sup>(1)</sup>, R.T. Melis<sup>(1)</sup>**

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(2) McCord Centre for Landscape, School of History, Classics and Archaeology, Newcastle University, Newcastle upon Tyne, United Kingdom

### **Landscape spatial occupation patterns and resource availability in Nuragic Sardinia (Italy): a glimpse of Bronze Age land use strategies.**

*Keywords: Bronze Age, digital geoarchaeology, natural resources, settlement patterns*

The choices made by populations when settling inside a territory typically follow precise rules dictated by the socio-political needs of the communities, but also by the physical features and resources present in the landscape itself. Survival strategies control much of this decision process. The passage to the Bronze Age from Neolithic cultures has allowed the transition to new land use strategies. The expansion of metallurgy, the development of new farming tools and techniques and the consequent population increase sparked the transition to new ways of occupying the landscape, which in turn required adapting settlement choices to the shift in importance of different resources. The recent developments in digital geoarchaeology allow us to explore the link between settlement networks and physical variables with an improved approach and provide precise information on the subject.

Among Bronze Age cultures, the insular nature of Sardinia (Italy) allowed Nuragic communities to settle the landscape and develop land management strategies without the influence or interference of external populations. We investigated the southwestern portion of the island with an interdisciplinary approach that combines geosciences and spatial statistics tools in order to relate the distribution of Nuragic towers to the main geological and geomorphological features (topographic parameters, morpho-lithological units, soil pH and permeability, ore deposits, water network). Location choices for towers seem to indicate a preference not only for high topographic positions in low-elevation areas, but also for stable geological substrates and low slopes to improve their structural support. The association with water, permeable soils and ore deposits is also visible, implying a great attention of these populations to a careful management of the available resources. Tower concentrations also show a preference for areas easily reachable from coastal sites and the avoidance of rough terrain.

**[25] Matthieu Giaime<sup>(1,2)</sup>, H.M. Jol<sup>(3)</sup>, Y. Salmon<sup>(1)</sup>, A. Abu Hamed<sup>(1,4)</sup>, G.I. López<sup>(1,5)</sup>, L. Bergevin<sup>(3)</sup>, E. Sailer-Haugland<sup>(3)</sup>, P. Bauman<sup>(6)</sup>, A. McClymont<sup>(6)</sup>, M. Artzy<sup>(1)</sup>**

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(6) Advisian, Calgary, Canada

### **Late-Holocene coastal changes and their effects on settlement/anchorage patterns on Tel Akko (Israel)**

*Keywords: ancient anchorages/harbours; sedimentology; GPR; ERT; coastal changes*

Akko/Acre, a UNESCO World Heritage Site, is one of the oldest continuously inhabited sites in the eastern Mediterranean. Tel Akko was a major maritime centre of the southern Levant in the Second and most of the First Millennium BCE, after which it was relocated ca. 1 km to the west on the Akko promontory where the 'Old City' of the Crusaders, Saint-Jean d'Acre, is located. The natural and anthropogenic evolution of Tel Akko area is reflected by persistent geographical and habitation pattern vicissitudes. Presented here is an up-to-date palaeogeographical reconstruction of landscape/environmental changes of the Akko plain in order to understand the extent to which environmental pressures influenced the location of anchorages/harbours and concurrent habitation patterns. The approach is based on a detailed investigation of subsurface sediments combining biostratigraphy, archaeological material identification, and radiocarbon dating of sediment cores with electrical resistivity tomography and ground penetrating radar. We highlight how the local population made use of pre-existing natural conditions and adapted to the changing coastal environment. Following constant sedimentary input and simultaneous coastal progradation of the Akko coastal plain, anchorage and harbour facilities serving the inhabitants were repositioned. While the 2<sup>nd</sup> Millennium BCE anchorage was located south of the tell, the late-1<sup>st</sup> Millennium anchorage was relocated to its west. Vicissitudes in settlement patterns noted by the archaeological surveys and excavations were, most likely, a consequence of paleoenvironmental changes.

**[26] Laura Tomé<sup>(1, 2)</sup>, M. Jambrina-Enríquez<sup>(1, 3)</sup>, N. Égüez<sup>(1)</sup>, A.V. Herrera-Herrera<sup>(1)</sup>, A. Blanco-González<sup>(4)</sup>, C. Mallo<sup>(1, 2, 5)</sup>**

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### **Early Iron Age olive oil production in Iberia? Microscopic and molecular geoarchaeology at Cerro de San Vicente village (Salamanca, Spain)**

*Keywords: micromorphology; lipid biomarkers; domestic archaeology; dwellings; microcontextual approach*

Cerro de San Vicente is an Early Iron Age village (ca. 600 BCE) located in the Iberian Northern Plateau (Salamanca, Spain). Excavations in the site have unearthed diverse areas of domestic activity, including dwellings and architectural structures of unknown functionality. In this study, we analyzed two of these structures using archaeological soil micromorphology and lipid biomarker analysis as geoarchaeological tools for the study of the human past. We also tested a new sampling method involving the collection of two adjacent sediment blocks, one for micromorphology and the other for lipid biomarker analysis. The latter was subsampled in the lab. Our high-resolution results have allowed us to link the sampled structures with possible manufacture or storage of olives, olive oil or

other olive by-products, an undocumented economic activity for this period and place. We have also identified the presence of conifer and angiosperm woody vegetation, as well as a behavioral change related to residue management and fire use. Additional micromorphology and lipid biomarker samples need to be collected from the site in order to determine if the production or storage of olive by-products is spatially constrained. This study contributes to the relatively scarce microcontextual data from Iron Age sites and shows the potential of the approach towards its future consolidation.

## Session 8

Tuesday 18<sup>th</sup> of May  
11 am

### [27] **Barbora Wouters**<sup>(1)</sup>, P.L.K. Trant<sup>(2, 3)</sup>

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#### **Geoarchaeological research in Ribe's Northern Emporium, Denmark – a micromorphological and geochemical study of a highly stratified urban context, AD 700 – 900**

*Keywords: micromorphology; geochemistry; pXRF; early medieval towns; stratigraphy*

This paper explores how geoarchaeological methods have contributed to, and in some cases altered, our understanding of Denmark's earliest town. As one of the famous early medieval "emporia", Ribe played an important and continued role in international trade with other northwestern towns of the period, such as Quentovic or Dorestad, as well as towns in the Baltic, for example Wolin. In 2017-2018, a research excavation was carried out at the small square of Posthustorvet, covering the area between the old Post Office and Ribe's Art Museum. The excavation unearthed ca. 2.3 m of settlement deposits dating from the 8<sup>th</sup> to 10<sup>th</sup> century CE. During the excavation, well-preserved, thin (micro)laminations as well as thoroughly homogenized strata were encountered, both of which require geoarchaeological techniques in order to answer questions about their formation, character and to inform their interpretations. In particular, questions relating to the emporium's establishment and earliest phases; the formation of a famous homogeneous deposit, so-called "phase C"; the extent and functions of buildings; and the formation of the microlaminated deposits of the younger phases of the settlement were addressed through the application of micromorphological and geochemical analyses. These were contextualised in a research design that included systematic 3D laser scanning, high resolution dating using dendrochronology and <sup>14</sup>C processed using Bayesian modelling, as well as sieving of all excavated sediment, botanical analysis and entomology. Our main results include insights into the settlement's earliest habitation traces; an understanding of the changing use of space throughout the settlement's existence; an investigation of commonly used building materials and their (non-)preservation; the micromorphological characterization of repeated burning events, collapses and missing floors; a combined micromorphological and geochemical analysis of a house from the early 9<sup>th</sup> century; and the assessment of the settlement's highly disturbed youngest strata, contributing to questions regarding the town's final stages.

### [28] **Mario Gutiérrez-Rodríguez**<sup>(1)</sup>, M.A. Lechuga Chica<sup>(1)</sup>, M.I. Moreno Padilla<sup>(1)</sup>, J.P. Bellón Ruiz<sup>(1)</sup>

(1) Instituto Universitario de Investigación en Arqueología Ibérica, Universidad de Jaén, Jaén, Spain

#### **Multiscalar spatial and geoarchaeological analysis of the main roman road in Hispania. The Via Augusta where it passes through the Ianus Augustus (Mengíbar, Spain)**

*Keywords: roman road; Via Augusta; GIS; geoarchaeology; micromorphology*



Roman roads are omnipresent in the Mediterranean basin. Despite the methodological advances achieved, interdisciplinary studies including geoarchaeological techniques are still rare. The aim of this study is to offer a multiscale spatial and geoarchaeological analysis of an outstanding Roman road in order to characterise the raw materials and construction techniques used to build it and their evolution over time. Our research focuses on the Via Augusta, the longest road in Roman Hispania, where it passes through the Ianus Augustus (Mengíbar, Spain), a monumental complex on the frontier between the provinces of Baetica and Tarraconensis. Archaeological excavations of this road have revealed vertical and horizontal stratigraphic variations, suggesting the presence of several transit surfaces, repair work, and a long biography, all of which constitute a true palimpsest. A protocol was designed ranging from the macroscopic level, to identify the layout of the Via Augusta in the landscape using remote sensing techniques, to a meso and microscale analysis focusing on the geoarchaeological characterisation of the deposits. GIS cartographic products were used in the macro- and mesoscale analyses, including a DEM from LIDAR data and Photogrammetry using UAV. On the microscale, micromorphology revealed six overlying roads and their construction techniques. Micromorphology,  $\mu$ -XRF and the study of the textural parameters of the deposits allowed us to identify the raw materials used and their sources, as well as the specific features generated during the construction and use of the road. The results show how the technical solutions used survived as a tradition for centuries.

**[29] Enrique Fernández-Palacios<sup>(1, 2, 4)</sup>, C. Rodríguez<sup>(1)</sup>, C.M. Hernández<sup>(2)</sup>, A.V. Herrera-Herrera<sup>(1)</sup>, M. Jambrina-Enríquez<sup>(1, 3)</sup>, J.F. Navarro<sup>(2)</sup>, E. Marrero<sup>(2)</sup>, C.E. Miller<sup>(4, 5, 6)</sup>, C. Mallol<sup>(1, 2, 7)</sup>**

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### **Belmaco Cave: an aboriginal fumier deposit on La Palma (Canary Islands)**

*Keywords: dung; fumier; micromorphology; n-alkanes; stabling*

Belmaco Cave is an aboriginal rock-shelter site located in the southeastern part of the island of La Palma (Canary Islands). The site, which dates from the end of the 9<sup>th</sup> century to the 14<sup>th</sup> century AD, has been investigated since the mid-20<sup>th</sup> century and is a key reference locality on the island. Macroscopically, the stratigraphy is a succession of alternating burnt, partially burnt, and unburnt thin layers suggestive of a fumier-type deposit. Fumiers, a common type of archaeological sedimentary deposit in recent prehistory, are normally located in rock shelters, which were used by shepherds to protect their livestock. During their formation, they underwent recurrent maintenance burning. Here we present the first high-resolution geoarchaeological study combining soil micromorphology and lipid biomarker analysis of a fumier deposit aimed at site formation process characterization. Our results show recurrent goat/sheep habitation and maintenance activity throughout the sequence represented by interstratified layers of unburned dung, charcoal-rich sediment, and dung ash. A minimum of 10 stabling episodes have been identified across a period of 200 to 400 years. Lipid

biomarker data shows that the goat/sheep diet at Belmaco Cave was mainly composed of herbaceous plants.

**[30] Yannick Devos<sup>(1)</sup>**

(1) Maritime Cultures Research Institute (MARI), Vrije Universiteit Brussel, Brussels, Belgium

**Conquering the Darkness: 20 years of geoarchaeological research on the Dark Earth from the historical centre of Brussels (Belgium)**

*Keywords: Urban Dark Earth; micromorphology; spatial analysis; soil pollution*

Since several decades many European historical town centres have been affected by major transformations due to city planning and reorganisation of space. This frequently results in the removal of important quantities of soils and sediments, including the ubiquitous Dark Earths: thick, dark coloured, humic, homogeneous units that cover large surfaces and that are often rich in archaeological remains, including 'floating' archaeological structures (Nicosia et al., 2017). Due to a lack of internal stratigraphy their interpretation composes a major challenge for urban archaeologists. Present contribution intends to highlight how geoarchaeological research on the Dark Earth from the historical centre of Brussels contributes to our knowledge on several aspects of town development. Whereas the research initially focused on the understanding of the stratigraphy of each individual site and the reconstruction of the individual site biographies, the systematic study of the urban Dark Earth has widened the perspective. It permitted to come to a better understanding of the organisation of space, as the location of houses, gardens, quarries, crop fields and grasslands can be detailed for different time periods. Other thematic issues that have been dealt with recently are soil pollution, waste management and vegetal food supply.

## Session 9

Tuesday 18<sup>th</sup> of May  
2 pm

### [31] Hans Huisman<sup>(1, 2)</sup>

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#### **Lost again? A future for micromorphological thin sections**

*Keywords: micromorphology; thin sections; curation*

Archaeological artefacts are usually stored and curated after the end of a research project. This is logical, as these remains form a valuable resource if new research methods come available, or when new research questions arise. Moreover, as tangible remains of the past they can play a part in bringing the greater public in contact with their heritage.

It is remarkable therefore, that micromorphological thin sections – and other types of specialist samples such as archaeobotanical remains – seem too often be treated differently. The wealth of new methods that are nowadays applied to micromorphological samples (mCT scanning, mXRF, mFTIR, bioorganic analyses) shows that their scientific value is undiminished. Moreover, these materials form as much tangible remains of the past as artefacts and bones.

Still, in many cases thin sections and sample blocks from archaeological sites stay with the specialist researcher who studied them, as reference collection or training or teaching material. However, I will show with a series of examples from the Netherlands that there is a serious danger that these unique and valuable objects in the long run will be forgotten, misplaced, lost or even destroyed. To prevent this from happening, and to ascertain the long-term curation and potential re-use of these thin sections and soil blocks, I have been advocating that thin sections and impregnated blocks are treated the same as other archaeological remains: Stored and curated together with the archaeological artefacts in an archaeological depot. From there, they can be loaned to anyone who wants to study them. And those thin sections that are valuable as reference or teaching material can be loaned out on a more permanent basis. In this way, the long-term survival of these valuable materials is ascertained.

### [32] Pedro García<sup>(1)</sup>, R. Aray<sup>(2)</sup>, J. Hernández-Aceituno<sup>(2)</sup>, C. Mallo<sup>(1)</sup>

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#### **Soil Micromorphological image classification using Deep Learning: the porosity parameter**

*Keywords: soil micromorphology; archaeology; deep learning; image classification; microstructures*

Here we present our progress in the training of several Convolutional Neural Network (CNN) models for archaeological soil micromorphology. The aim of our project is to provide aid to the micromorphological description process through a tool that allows automatic identification of components and microstructures in soil and sediment thin sections. So far, we have created a Deep

Learning System based on Convolutional Neural Networks (CNN) to classify different porosity types. The classification system is based on JPG format photomicrographs and ongoing tests include high-resolution, full thin section scans. The CNN models were built using TensorFlow and Keras Deep Learning libraries. All code is publicly available at [github.com/jhaceituno/CNN-soil-micromorphology](https://github.com/jhaceituno/CNN-soil-micromorphology). Manual tagging of the target feature (porosity) was made using the LabelMe application. The output yielded a median error of 2%. Currently, we continue to train the CNN to increase its accuracy in pore classification. In the future, we will incorporate classification of other micromorphologically relevant elements such as different archaeological materials (bone, flint, pottery and charcoal).

**[33] David E. Friesem<sup>(1, 2, 3)</sup>, N. Teutsch<sup>(4)</sup>, M. Weinstein-Evron<sup>(1)</sup>, R. Shimelmitz<sup>(1)</sup>, R. Shahack-Gross<sup>(2)</sup>**

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### Identification of bat guano and pigeon droppings in archaeological cave sites

*Keywords: bat guano; pigeon droppings; prehistoric caves; diagenesis; micro-geoarchaeology*

Caves in different environments, from tropical to temperate, are often used as a habitat for birds and bats. As a result, bat guano and bird droppings are not only a major source of cave deposits, but also trigger significant chemical alterations (diagenesis) due to their decomposition, that can greatly affect the preservation of archaeological materials as reported from many Palaeolithic cave sites. While the diagenetic processes associated with bat guano degradation are quite well understood, the identification of partially preserved and/or burnt guano residues in archaeological cave sites has not received much attention. Here we present micromorphological and chemical guidelines to assist the identification of organic remains in Palaeolithic caves. We examined modern guano of: (1) insectivorous bats; (2) frugivorous bats; and (3) pigeon; in fresh, charred and ashed forms. Although the combustion of guano presents similarities to other organic-based burnt deposits found in archaeological sites, a careful micromorphological study of such features can reveal whether or not it originates from guano.

**[34] Mareike Stahlschmidt<sup>(1)</sup>, V. Aldeias<sup>(2)</sup>**

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### A geoarchaeological perspective on ancient sediment DNA from archaeological contexts

*Keywords: aDNA; archaeological sediments; site formation; micromorphology*

Recent genomic research has revealed that ancient Deoxyribonucleic acid (aDNA) can be recovered not only from bones but also from archaeological sediments, including aDNA of mammals and early humans (Slon et al 2017, Gelabert et al 2021). However, potential leaching presents an issue and it is still an open question what this aDNA is actually retrieved from - microscopic bones, faecal matter, organic materials or as free DNA absorbed to minerals. Many minerals common in the archaeological sedimentary record have been shown to absorb DNA, including apatite, calcite, clay,

humic acid as well as silica. This absorption can protect DNA from degradation and is controlled by many factors such as pH, salt concentration, moisture content, light and temperature (Nagel et al 2018). As each archaeological site is formed by a unique set of formation processes, their potential to preserve DNA will vary widely. There is also a clear need to assess the *in situ* nature of the sampled sediments, something that is far from trivial in archaeological sediments where bioturbation and other post-depositional processes can be expressed at the mm- and  $\mu$ m-scales. Using microcontextual analyses, we can disentangle these processes and assess a site's potentials for DNA preservation. Here we present pilot results on sediment aDNA from several contexts, discussing possible indicators for DNA preservation, ways to assess DNA integrity and sampling strategies. Furthermore, we explore how we can use this new dataset to gain deep insights into the formation of archaeological sediments and people creating these sediments.

**[35] Irini Sifogeorgaki<sup>(1)</sup>**

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### **Site formation processes at sandstone and quartzite rockshelters: a geoarchaeological review**

*Keywords: geoarchaeology; sandstone/ quartzite rockshelter; site formation processes; taphonomy; geoarchaeological methods*

The development and evolution of cave and rockshelter archaeological sites has been a subject of many geoarchaeological studies. Karstic cave and rockshelter deposits have been intensively studied, while similar contexts in quartzitic bedrocks (sandstone and quartzite) are comparatively overlooked. In this talk, I highlight common aspects in the formation of quartzitic rockshelters around the world by carrying out an extensive literature review. I conducted a comparative analysis of the geoarchaeological studies on sandstone and quartzite rockshelter archaeological sites taking into account aspects including the climatic setting, bedrock mineralogy, site preservation (charcoal, bone), as well as geoarchaeological methods applied. The taphonomy and preservation condition of the sites is often affected by the moisture content of the sediments which is usually related to the bedrock hydraulics of the rockshelter. In addition, I review a variety of techniques used when conducting geoarchaeological studies on quartzitic rockshelters. Standard bulk sediment analyses like granulometry, pH, and Loss on Ignition can provide important insights to the formation processes. To fully assess the depositional and post-depositional processes, micromorphological analysis needs to be conducted. Finally, I suggest a workflow template for researchers (both archaeologists and geoarchaeologists) working on sandstone and quartzite rockshelter excavations.

## Session 10

Wednesday 19<sup>th</sup> of May  
9 am

**[36] Katarína Adameková<sup>(1)</sup>, J. Petřík<sup>(1)</sup>, L. Petr<sup>(2)</sup>, P. Kočár<sup>(3)</sup>, J. Bartík<sup>(4)</sup>, T. Chrástek<sup>(4)</sup>**

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**Man and a river in the Middle Ages: a unique sequence of floods, human habitation and soil formation on the floodplain of the river Morava**

*Keywords: floodplain sediments; pedogenesis; Dark Earths; settlement dynamics; Great Moravia*

Floodplain deposits of the river Morava were uncovered during rescue excavations in the Czech town of Uherské Hradiště. They contain a sequence of buried soil horizons showing signs of considerable human influence. This sedimentary sequence is a record of interactions between human activities and natural processes taking place in the Holocene, so it allows us to directly examine the evolution of the environment in relation to settlement dynamics on the floodplain. The sequence was studied by a multi-proxy approach based on a combination of archaeological evidence, soil micromorphology, and physical, geochemical and palaeobotanical analyses supplemented with radiocarbon and OSL dating. Calm periods of soil formation were alternated by periods of flooding and floodplain aggradation. The oldest soil horizon has been dated to the 8<sup>th</sup> century AD. The site was probably an important trading centre since this period, as indicated by findings of coins and a set of lead weights. A more developed buried soil horizon formed in the first half of the 9<sup>th</sup> century, when the locality belonged to an important settlement agglomeration of the Great Moravian Empire. During the 9<sup>th</sup> century, the site was flooded, as is reflected by the presence of a sand layer across the site. The following soil horizon, containing younger Great Moravian ceramics, has been dated to the second half of the 9<sup>th</sup> century. This horizon, bearing signs of the so-called European Dark Earth, formed a levelled surface on which the Mediaeval town of Uherské Hradiště was founded after 1211 AD. The town got hit by another flood in the 13<sup>th</sup> century. Despite repeated flooding, the settlement in the area was renewed repeatedly. Together with evidence of long-distance trade, this testifies to the importance of the place located on the commercial waterway of the river Morava.

**[37] Noemí Silva-Sánchez<sup>(1, 2)</sup>, M. Fernández Ferreiro<sup>(3)</sup>, E. López-Salas<sup>(4)</sup>, T. Kinnaird<sup>(5)</sup>, S. Turner<sup>(6)</sup>, J.C. Sánchez Pardo<sup>(3)</sup>**

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## **A dialog between nature and texts. Diachronic evolution of a monastic landscape. A novel application at Samos Abbey (NW Spain)**

*Keywords: palaeoenvironment; monastic studies; geochemistry; palynology; agrarian history*

Monastic landscape studies, even nowadays, still largely focus on written evidence and detailed site surveys of architectural remains. Some efforts on integrating historical sources and palaeoecological approaches have been made in those areas where exceptional environmental archives such as peatlands are common, and in such a way, likely to find clues of emblematic monuments such as monasteries but, many monasteries lack the presence of such extraordinary environmental archives in their immediate vicinity. At these sites, sediment and agrarian terrace sequences are the best option to approach the environmental fingerprints of monastic agrarian history. In this paper, we present a diachronic agrarian history of the lands around Samos abbey (NW Spain) by combining palaeoenvironmental and text based approaches. OSL, geochemistry and palynology analysis of an agricultural terrace and a sediment sequence located in the surroundings of the abbey, were considered together with historical text analysis of “Tumbo de Samos” and “Apeos de Samos” books. The main objectives were to: 1) evaluate the role of monastic activities in shaping the Samos landscape and 2) get a better understanding of the interplay between proxy based and written sources of information.

Written evidence of intense agricultural activity existed from the early middle ages, although the strong environmental transformations occurred during the 17<sup>th</sup> century in the lands near the monastery, and not so well documented in the texts, seemed to have masked their printing in the environment. Our results show how the interplay between palaeoenvironmental and text based approaches, resulting both fragmentary, allowed us to reconstruct the diachronic evolution of a monastic landscape.

**[38] Daniel Fallu<sup>(1)</sup>, P. Zhao<sup>(2)</sup>, A. Brown<sup>(1)</sup>**

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## **Geochemical signatures of terrace construction and cultivation: preliminary results of the TerrACE Project**

*Keywords: agriculture; chemostratigraphy; FTIR; pXRF; soil organic carbon*

Cultivation terraces are a ubiquitous part of the landscape in many parts and a key part of the agricultural toolkit. Human activities on terraces will result in variations in vegetation and changes in soil properties (including the addition of soil, manure, and changes in moisture regimes) which result in variations in plant microremains (phytoliths, DNA) and in soil chemistry (elemental concentration, mineralogy, organic carbon storage). While these signals represent the total effect of human and natural processes, in some cases can be directly related to human intervention. Consistent use and reuse of terraces means that stratigraphic sequences are truncated and mixed, resulting in a palimpsest of these environmental signatures. Special attention to process is required to generate soil histories which are useful for archaeological investigation.

In this presentation, we introduce a toolkit for unraveling the use of ancient agricultural terraces, combining geochemical, botanical and geochronological analyses. We present preliminary results of the geochemical analysis of sites in various climate zones across Europe. The results of pXRF, FTIR, and SOC analyses are compared against pOSL curves for excavated terrace profiles to distinguish between events and processes which resulted in geochemical change in the soil column. Preliminary results



demonstrate clear differences in signal for modern and historical practices. Soil horizonation and plough-zone mixing are also visible in the geochemical signature, as well as past soil conditions affecting the preservation of plant microremains. Continued research into the geochemical signature of ancient agriculture will not only aid in the further analysis of ancient agricultural practices, but assist in the conservation of terraced landscapes.

**[39] Tiziana Matarazzo<sup>(1)</sup>, G. Boenzi<sup>(2)</sup>**

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(2) Soprintendenza Archeologia, Belle arti e Paesaggio per il comune di Napoli, Naples, Italy

### **Micromorphological analysis of agricultural features sealed by several eruptions of the Phlaegrean volcanic system (Campi Flegrei) in Southern Italy**

*Keywords: micromorphology; Eneolithic; agricultural features; paleosurfaces; volcanism*

Agricultural fields, especially ancient plow fields, are difficult to identify and study as they are constantly modified during their use and affected by post-depositional processes (natural and anthropic) that alter the original composition and structure of the soil and often eliminate their signature altogether. Volcanic eruptions have played a key role in the preservation of agricultural features in the Campania region (southern Italy).

During the construction of a Metro station at Piazza S. Maria degli Angeli in downtown Naples, field archaeologists uncovered unusually well-preserved agricultural features such as ditches and plough-fields dating to the Eneolithic period. The features were sealed by two volcanic eruptions, Paleoastroni 2 (4,712-4,757 cal yrs BP) and Agnano Monte Spina (4,482-4,625 cal yrs BP), both derived from the Phlaegrean volcanic complex, one of the major volcanic systems in the area. This study investigates the formation of these agricultural paleosurfaces through the analysis of three micromorphological samples.

The analysis revealed micromorphological features such as dusty clay coatings, compact microstructure, and calcium carbonate coatings in the voids, that reflect both anthropogenic and post-depositional processes. This micromorphological study of this exceptionally preserved site contributes to the understanding of ancient agricultural practice during the Eneolithic in southern Italy.



## Session 11

Wednesday 19<sup>th</sup> of May  
10 am

**[40]** Joeri Kaal<sup>(1)</sup>, M. Suárez Abelenda<sup>(2)</sup>, D. Stump<sup>(3, 4)</sup>, C. Ferro-Vázquez<sup>(5)</sup>

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### **Multiproxy geoarchaeological study of agricultural sediment traps in the Iron Age ruins of Engaruka (Tanzania)**

*Keywords: soils; sediment traps; agricultural management; SOM; geochemistry*

The 13<sup>th</sup>-18<sup>th</sup> centuries agricultural site of Engaruka (northern Tanzania) consists of a sophisticated runoff system based in the landscape scale erosion-sedimentation cycle. Taking advantage of the differences of the catchment slope and climate gradients, new fertile soils, apt for cultivation, were created in the lowlands by intentionally accumulating mineralogically fertile sediments from the nearby and much wetter Ngorongoro mountains. Here we study a pedosedimentary sequence formed through this system, using a multiproxy approach that included the molecular characterization of soil organic matter (OM) by pyrolysis-GC-MS, elemental and isotopic composition (XRF and IRMS) and magnetic susceptibility (MS) of bulk sediments. The use of multivariate statistics (PCA) allowed us to identify the processes that control the composition of the pedosedimentary record and thus to elaborate on the use and management of these agricultural sediment traps. Results show evidence of levels of OM decay that partially eliminated information on past vegetation due to poor preservation of lignin, which could only be recognized for the youngest 40 cm of the sequence. Also markers of well-preserved microbial biomass (chitin, bacterial fatty acids) are concentrated in the uppermost layers. Nevertheless, several observations show the value of this kind of approach, notably a layer (60-80 cm) with fine-textured sediment, high EC and OM with high proportions of phytadienes and alkylnitriles, which is interpreted as a signal of a low energy depositional environment, with OM from aquatic organisms (algae) under waterlogged (probably standing water) conditions. The amount of pyrogenic OM and the MS are also higher in this layer, suggesting the presence of fire-affected sediments. In the whole sequence, the  $\delta^{13}\text{C}$  ratio is controlled by the abundance of carbohydrates (heavy carbon footprint), which are most abundant between 40 and 60 cm depth and probably reflects the return to a non-waterlogged environment.

**[41]** Carol Lang<sup>(1, 2)</sup>, T. Kabora<sup>(3)</sup>, C. Ferro-Vázquez<sup>(4)</sup>, D. Stump<sup>(1, 3)</sup>

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## **Geoarchaeological study of the viability of an abandoned agricultural landscape to once again become productive. The case of Engaruka (N Tanzania)**

*Keywords: terraced agriculture; micromorphology; East Africa; sustainability*

It has long been accepted that the largest abandoned irrigated and terraced landscape in East Africa is located at Engaruka in Tanzania. It is presumed that this 13<sup>th</sup>-18<sup>th</sup> century vast, agricultural system, formed through the capture of alluvial sediments, was in a degraded state and unsuitable for modern crop production- While it is increasingly evident that there is a need for global food security, a point substantiated by the UN-FAO, there are few studies that focus on the current and future health of agricultural soil systems in relation to their past management, the legacy of past agriculture. This gap in data has led to urgent calls for case studies to be undertaken, not only on the visible morphology of historic agricultural landscapes, but on the unseen fundamental functions and properties of their soil, such as the physical properties and chemical composition.

It is, however, not simply a case of analysing soils from the past and comparing them to today's soils, as many farming areas have been under constant till for decades, in some instances centuries. Thus, getting a 'snap shot' of inherent agricultural management techniques, that form a baseline for research into how these soil legacies are having a bearing on today's farming practises, is challenging. Through the application of geoarchaeological techniques, this presentation seeks to address the urgent call for pedological case studies in this regard. Evidence will be offered from the investigation of two adjoining agricultural locations: an area of abandonment, and a small holder farm; both located within the sediment capture landscape at Engaruka. This research will determine the agricultural viability of this abandoned and 'degraded' landscape, while identifying the changes in soil properties produced by past management practises, which are impacting present and will influence soil functions and management strategies in the future.

**[42] Gianni Gallelo<sup>(1, 2)</sup>, C. Ferro-Vázquez<sup>(2, 3)</sup>, Á. Hernández Sánchez<sup>(4)</sup>, M. Ramacciotti<sup>(1, 4)</sup>, S. Chenery<sup>(5)</sup>, C. Lang<sup>(6, 2)</sup>, S. Thornton-Barnett<sup>(2)</sup>, T. Kabora<sup>(7, 2)</sup>, M.E. Hodson<sup>(7)</sup>, A. Morales<sup>(4)</sup>, D. Stump<sup>(2, 7)</sup>**

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## **Tracking sedimentary processes through REE geochemistry at an agricultural Iron Age site in N Tanzania**

*Keywords: rare earth elements; geochemistry; sediment; weathering; Tanzania*

Previous research using the content of rare earth elements (REE) in bulk soil samples has suggested that REE geochemistry can be used for recognizing sediment provenance in archaeological sites. Here we seek to test this hypothesis by studying the REE geochemistry of three soils with different degrees of pedogenetic development at a sedimentary basin in the 13th-18th centuries agricultural site of Engaruka (N Tanzania).

The study location comprises a small, half-moon shaped catchment, in which all the sedimentary materials that accumulate in the thalweg come necessarily from the small hills to its N and E. The sediment accumulation was enhanced by anthropogenic structures built for capturing detritus derived from up slope weathering and erosion which was then used for cultivation. The materials accumulated behind these traps thus provide a record of the erosion-sedimentation processes of this small area.

ICP-MS and XRF analyses have been carried out for major, minor and trace elements (including REE) in bulk samples of all the sedimentary layers, as identified in the field, from three sampling spots that form a topographic catena. We calculated REE ratios and Ce and Eu anomalies, and checked their correlation with major and minor elements. We also used multivariate statistics for discerning the compositional differences between samples.

The results show differences in the REE signature of the three sampling locations that, together with correlations between REE and other elements, suggest that the REE abundance in bulk samples reflects the degree of weathering and pedogenesis, and not the source of the sediments. Additional physical and chemical treatments are needed for isolating the signal of the source rocks, and thus for assessing the sediments' provenance.

**[43] Tabitha Kabora<sup>(1)</sup>, D. Stump<sup>(2)</sup>, J. Wainwright<sup>(3)</sup>**

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(3) Department of Geography, Durham University, United Kingdom

### **Modelling sediment transport and accumulation in archaeological sites**

*Keywords: sediment transport; agent-based modelling*

Recent research into the 15<sup>th</sup>-18<sup>th</sup> century CE site of Engaruka in Tanzania has identified that many of the former farming plots that were previously considered drystone agricultural terraces were instead sediment traps. Stratigraphic excavations of these traps show that they were built by constructing low drystone walls adjacent to either natural or artificial water courses in order to capture fine alluvial sediments entrained within water flows. In the northern area of the site sediments were accumulated to a depth of up to 700 mm, while in one area in the south of the site over 2 m of deposits were accumulated over at least a three-hundred-year period. Although a combination of stratigraphy and absolute dating can discern the broad sequence and timing of sediment capture they cannot determine sediment-accumulation rates, and these techniques are too time consuming to be used to map the development of over 9 km<sup>2</sup> of sediment traps. The ESTTraP agent-based model provides these data by simulating sediment accumulation under different hydrological conditions. The model results suggest that the fields can be constructed over a short period of time, approximately 1 - 3 months per 6 × 6 m field, and that it would take between 8 to 13 years in periods of high water availability, and up to 27 years during prolonged dry periods, to construct a block of 90 fields covering 3,000 m<sup>2</sup>. These results define the amount of time needed to construct individual fields, and suggest that farmers constructed blocks of fields concurrently rather than sequentially expanding across the landscape. The ESTTraP model presents an important resource in the assessment of sediment dynamics and patterns of field development, is relevant to a range of archaeological sites worldwide that include intentional or unintentional alluvial deposition, and has applications for modern landscape management.

## Session 12

Wednesday 19<sup>th</sup> of May

2 pm

### [44] Luc Vrydaghs<sup>(1)</sup>, M.J. Hodson<sup>(2)</sup>, R. Hermans<sup>(1)</sup>, Y. Devos<sup>(1)</sup>

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#### **Do phytoliths become auto-fluorescent upon heating?**

*Keywords: phytoliths; autofluorescence; fire; fluorescence microscopy; heating*

Different methods have been applied to identify whether phytoliths have been fired and/or heated: morphological alterations, changes in colour and opacity, refractive index and Raman spectroscopy. Besides the fact that some of them are quite difficult to apply on soil and sediment thin sections, none provide satisfactory results for sufficient discrimination between burned and unburned phytoliths. Newly formed phytoliths are believed to show no auto-fluorescence. We surveyed phytoliths in thin sections taken from a variety of modern and archaeological contexts in Northern Europe. Unheated material shows no autofluorescent phytoliths while the surrounding organic material strongly fluoresces. Our observations of combustion features and burned material revealed that phytoliths typically appear to become auto-fluorescent upon heating. Based upon these observations experimental work is currently undertaken to determine the temperatures and the environmental conditions under which phytoliths fluoresce. This signal may then become an important proxy complementing the previously developed techniques. As such, integration of various proxies can provide a systematic and straightforward method to track evidence of fire and heating of phytoliths within archaeological contexts.

### [45] Magnus M. Haaland<sup>(1, 2, 3)</sup>, S.M. Mentzer<sup>(3, 4)</sup>, E.C. Velliky<sup>(1, 2)</sup>, C.E. Miller<sup>(2, 3, 4)</sup>

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#### **Characterizing microscopic ochre fragments at Middle Stone Age sites: implications for evaluating *in situ* ochre processing and use**

*Keywords: ochre; micromorphology; micro-XRF; micro-FTIR*

Ochre is a colloquial term used to describe a series of ferruginous rocks that typically produce brightly coloured streaks. The earliest use of ochre dates back to ca. 300 kya in Africa and its procurement is often associated with the emergence of complex cognition amongst early Homo sapiens. Powder production through intensive grinding was likely the primary motivation for ochre acquisition amongst prehistoric hunter-gatherers. At many archaeological sites, ochre powder is regularly encountered, often as part of rock paintings or as surface residues on archaeological

artefacts. Less frequently reported, although often observed during excavation, is the occurrence of sand-sized ochre fragments dispersed within the archaeological sediments. At multiple Middle Stone Age (MSA) sites in South Africa, for example, microscopic ochre fragments have been documented within their well-preserved occupation deposits. In these contexts, the ochre powder typically forms small, localized patches of brightly coloured sediments (1 m). To date, few *in situ* ochre powder contexts have been systematically documented or formally investigated. To better understand how these *in situ* ochre deposits originally formed, and to document their occurrence, distribution, compositional range, we present here an analytical framework capable of identifying and characterizing microscopic ochre fragments found within archaeological sediments. Specifically, we employ a suite of microanalytical techniques (micromorphology, micro-XRF, mi-FTIR, micro-GIS) that allows us to accurately map and describe the texture, mineralogy, and elemental composition of individual, sand-sized ochre fragments found in oriented micromorphological block samples. Our preliminary results suggest that this type of multi-scalar and micro-contextual investigation of *in situ* ochre deposits not only enables us to evaluate their depositional setting, structural preservation, and geochemical characteristics, but also their behavioural significance in regard to on-site ochre processing and use.

**[46] Virginie Renson<sup>(1)</sup>, H. Neff<sup>(2)</sup>, A. Martínez-Cortizas<sup>(3)</sup>, J.P. Blomster<sup>(4)</sup>, D. Cheetham<sup>(5)</sup>, M.D. Glascock<sup>(1)</sup>**

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#### **Using isotopes of lead and strontium to source ceramics – application in Mesoamerican context**

*Keywords: lead isotopes; strontium isotopes; ceramics; provenance*

The isotopic systems of lead and strontium are two tracers used in archaeological science that have long contributed to our understanding of the circulation of artifacts and human mobility/migrations. In recent years, their efficiency to trace ceramics, and relate them to their raw material, has been evaluated and attested. In this study, the two isotopic systems are combined and applied to Olmec-style ceramic fragments dating to the Early Formative period (1500-1000 BCE) in ancient Mexico with the objective to explore how the isotopic approach can help to evaluate hypotheses related to their provenance. Isotopic analyses were conducted on a selection of forty ceramic fragments recovered at three sites located in different regions of Mexico (the Gulf Coast, southern Mexico and the Basin of Mexico). The results demonstrate that the isotopic approach: 1) discriminates between the different production centers, 2) identifies imports, and, 3) clearly assigns all fragments analyzed to their production centers or raw material. The study more broadly demonstrates that the isotopic geochemistry of ceramics is a powerful tool that should be considered in contexts where conflicting hypotheses exist about their provenance and exchange.

**[47] Andrew M. Zipkin<sup>(1)</sup>, M. Hipondoka<sup>(2)</sup>, P. Le Roux<sup>(3)</sup>, P. Wiessner<sup>(1)</sup>**

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## **Radiogenic strontium isoscape construction in the Kalahari and Namib deserts for provenience studies of ostrich eggshell ornaments**

*Keywords: isotope geochemistry; kriging; spatial analysis; provenience*

The radiogenic strontium isotope ratio  $^{87}\text{Sr}/^{86}\text{Sr}$  has been used to study mobility and migration, resource exploitation, and trade networks. Increasingly, researchers construct spatially explicit, landscape-scale interpolations of bioavailable  $^{87}\text{Sr}/^{86}\text{Sr}$  variation (i.e., isoscapes) to identify the origin of archaeomaterials. We report preliminary strontium isoscapes in the Kalahari and Namib deserts that will eventually facilitate estimation of the extent of hunter-gatherer social networks using  $^{87}\text{Sr}/^{86}\text{Sr}$  provenience of ostrich eggshell (OES) beads.

Our plant-based isoscape in the Namibian Kalahari is centered on the town of Tsumkwe and abuts the Botswana border. The current Empirical Bayesian Kriging interpolation is based on 111 specimens with  $^{87}\text{Sr}/^{86}\text{Sr}$  from 0.7144 to 0.7283. The most radiogenic samples are associated with Mokolian Stage bedrock 2 Ga to 900 Ma in age. These rocks contain granite and orthogneiss which, coupled with their age, explains the more radiogenic results and supports strong geological control of bioavailable Sr. The isoscape encompasses Ju/'hoansi San villages from which ethnographers collected OES beadwork during the 1950s-70s. A sample of 34 beads yielded  $^{87}\text{Sr}/^{86}\text{Sr}$  between 0.7168 and 0.7336, within the range of modern porcupine enamel from the area (0.7149-0.7360). The isoscape will be extended into Botswana to permit provenience studies of OES items from additional locations. The preliminary Namib isoscape is based on 70 plants. The study area surrounds but did not sample the Daures Massif. Plants were predominantly collected from areas mapped as Namibian stage and Cambrian period rock, which had statistically indistinguishable  $^{87}\text{Sr}/^{86}\text{Sr}$  results. However, Optimized Hot Spot Analysis found significant clustering of high  $^{87}\text{Sr}/^{86}\text{Sr}$  east-southeast of Daures and low  $^{87}\text{Sr}/^{86}\text{Sr}$  north-northwest of the massif. This suggests a possible marine strontium influence overprinting Sr from local bedrock weathering. Further sampling is required inside both of the existing isoscape study areas to adequately capture bioavailable Sr variation and investigate non-geologic directional phenomena.

**[48] Peter Mears<sup>(1)</sup>, C. Browne<sup>(1)</sup>, L. Wilson<sup>(1)</sup>**

(1) Biological Sciences, University of New Brunswick, Saint John, Canada

## **A growing role for statistics in lithic archaeology**

*Keywords: lithic provisioning, resource selection, statistical modelling*

The classification of stone tools and their raw materials has always been central to the field of lithic archaeology, but could more be done using statistical techniques to better understand the lives of those who made and used the tools? Our research is focused on building resource selection functions that determine causal influence for the use of stone tool raw material sources across a given landscape. This involves a geological and geographic description of what a source provides in relation to the archaeological site where an artefact was found, in concert with a multivariate statistical model that calculates which, if any, of these factors matters the most and how they interact. We demonstrate the potential and wider application for building complex resource selection functions in an archaeological context, showing how statistical techniques more familiar to wildlife ecology can be adapted and how challenges, such as low sample size and rare-event bias, can be addressed and overcome. Examples are drawn primarily from a dataset of over 15,000 lithic pieces excavated in 11 archaeological layers at a Middle Palaeolithic site in southern France, the Bau de l'Aubiesier. In a similar

way to how it has impacted modern biological research, we suggest that modern statistical analyses are poised to play an important role in developing modern lithic archaeology, bringing us closer to understanding the past behaviours of our prehistoric ancestors.

**[49] Nicholas Crabb<sup>(1)</sup>, C. Carey<sup>(1)</sup>, A. Howard<sup>(2)</sup>, R. Jackson<sup>(3)</sup>, M. Brolly<sup>(1)</sup>, N. Burnside<sup>(1)</sup>**

(1) University of Brighton, UK

(2) Landscape and Research Management, Stanmore, UK

(3) Worcestershire Archaeology, Worcester, UK

### **Remote sensing for the reconstruction and mapping of archaeological resources in alluvial environments**

*Keywords: remote sensing; environmental reconstruction; multispectral; SAR; LiDAR*

The deposition of fine-grained alluvial sediments within river floodplains can bury, conceal and preserve archaeological sites and features. Alluvial sediments are often thick (>1 m), preventing the detection of archaeological remains using common prospection techniques, such as shallow geophysical survey and aerial photography. Despite this, it is possible to determine zones of archaeological/paleoenvironmental potential in alluvial environments through deposit modelling; the recording of sub-surface sediments and stratigraphy, to identify geomorphological variation. This is normally achieved through intrusive investigations, such as boreholes/coring or trial trenching. However, the analyses of alluvial landform assemblages from remotely sensed data have significant potential to aid the investigation of these alluvial environments. This potential has yet to be systematically explored and with several recent technological advancements, such as the advent of small Unmanned Aerial System (sUAS) mounted instruments and increasing spaceborne capabilities, remotely sensed datasets are increasingly accessible for geoarchaeological research. This paper provides an assessment of contemporary remote sensing techniques, using a case study from the Lower Lugg valley in the UK. It focuses on the capability of different remote sensing techniques (e.g. Airborne LiDAR, Satellite multispectral, and Synthetic Aperture Radar (SAR)) to model geomorphological components of the river valley and identify archaeological potential. These datasets are compared with ground-based sediment sampling, to examine the relationship of near-surface and sub-surface sediment variability. The surficial responses of different valley components are analysed using computational image analysis to assess its potential to map subsurface sediment conditions. The results so far indicate that the application of remote sensing technologies can provide significant insights into the geomorphological complexity and variability of alluvial environments and subsequently facilitate a geoarchaeological assessment of their potential. However, the analyses also demonstrate this is best used in conjunction with targeted ground-truthing intrusive investigations, to provide more holistic models of these alluvial systems.



## Session 13

Wednesday 19<sup>th</sup> of May

4 pm

**[50] Manuel Arroyo-Kalin<sup>(1)</sup>, H.P. Lima<sup>(2)</sup>, M.C.P. Mariano<sup>(3)</sup>, G. Morcote Ríos<sup>(4)</sup>, E.G. Neves<sup>(5)</sup>, D.K. Wright<sup>(6)</sup>**

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(6) Department of Archaeology, Conservation and History, University of Oslo. Oslo, Norway

### The micromorphology of Amazonian Dark Earths - a comparative perspective

*Keywords: Amazonian Dark Earths; soil micromorphology; Amazonian Archaeology*

Amazonian Dark Earths (ADEs) were first described by scientists in the 19<sup>th</sup> century and have been widely reported by archaeologists and other field researchers in Amazonia. While the majority opinion among specialists affirms that ADEs are anthropic soils that formed mainly on land surfaces conditioned by ancient (pre-Colonial) sedentary settlement, recent suggestions have rekindled a potential ‘geogenic’ scenario to understand the high fertility of ADEs. Significant implications for our understanding of the ancient history of Amazonia follow from these two scenarios: if ADEs are anthrosols, they provide evidence of enduring landscape modification that created soil expanses with heightened fertility for plant cultivation. If, on the contrary, ADEs are geogenic, we need to account for their widespread presence in different landscape positions and widely-differing soil mantles and it follows that Amazonian indigenous peoples gravitated towards these locales due to their high inherent fertility. Here we present micromorphological analyses of ADEs from archaeological sites located in three different regions of the Amazon basin – the Araracuara region in the Colombian Amazon, the central Amazon region, and the lower Amazon region, all which represent human occupations taking place between 2,500-500 BP. We specifically focus on similarities and differences between these case studies, discuss the two models outlined above, and highlight the need for a more comprehensive treatment of ADE variability.

**[51] Kelly Brandão<sup>(1)</sup>, L.P. Furquim<sup>(1)</sup>, X.S. Villagran<sup>(1)</sup>, E.G. Neves<sup>(1)</sup>**

(1) Museum of Archaeology and Ethnology, University of São Paulo, São Paulo, Brazil

### Initial micromorphological and archaeobotanical data for the monticular complex of the southwestern Amazon - Sol de Campinas do Acre

*Keywords: Amazonian archaeology; earthworks; mound construction; soil micromorphology; archaeobotany*

Hundreds of pre-Columbian earthworks are found in the southwest of the Brazilian Amazon. Earthworks display various shapes and sizes and are integrated into a large network of roads that interconnect distant structures. Research in the region identified at least three types of earthworks, with diverse construction techniques and chronologies: ditches; walled enclosures; and earthen mounds.

To grasp the peculiarities of pre-Columbian engineering, it is necessary to study these structures at



different scales. This work presents the preliminary results of a combined geoarchaeological and archaeobotanical analyses of the “Sol de Campinas do Acre” (SCA) site. SCA is composed of 23 earthen mounds organized in an elliptical way around a square (or “plaza”), occupying an area of 15,000 m<sup>2</sup>, with three roads connecting to other similar structures. SCA is in an interfluvial zone near a small water spring and secondary river drainages. Despite the intense work of geospatial mapping, few sites of this type have been systematically researched in the area.

Radiocarbon ages from SCA show a succession of occupation and construction events dated between the AD 1000-1600. Micromorphological analyses of mound 11 indicate a clear intentionality in the choice of construction material, despite the overall homogeneity of local soil and sediment sources. The construction of the base of the mound involved mixing clay material with deliberately added iron nodules of up to 1 cm thick, possibly to improve the resistance of the structure to erosion. The upper layers were built over time with coarser material (silt and sand fractions) and few nodules, indicating a continuity of building practices over different generations. The archaeobotanical remains have an excellent preservation and analyses point to the use of a wide variety of local species, including Maize, Urucuri, Brazilian nuts and passion fruit. Our aim is to combine those proxies to better qualify the site’s construction process and approach issues regarding the time span of construction and permanence in this area.

**[52] Justin A. Holcomb<sup>(1)</sup>, L.M. Shillito<sup>(1)</sup>**

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#### **Microarchaeology of the Younger Dryas Cold Event in the Northern Great Basin, USA**

*Keywords: Paleoindian; Younger Dryas; micromorphology; Great Basin; Late Pleistocene to Early Holocene transition*

In North America, the Younger Dryas Cold Event (YDCE) occurred between 12,900–11,600 years ago (cal BP) marked by rapid changes in plant and animal communities that subsequently affected late Pleistocene and early Holocene human population organization and settlement dynamics. In the northern Great Basin, a shift to cold and wet climates appear to have positively affected Paleoindian foragers, but a lack of well-dated archaeological sites in the region hinders our ability to test this hypothesis. There is a need for high-resolution studies of deposits containing evidence of occupation spanning the late Pleistocene to early Holocene transition (LP/EH), especially those aimed at shedding light on the types of deposits, characteristics, and features that define the Younger Dryas. At the Paisley and Connley Caves, stratified deposits have yielded rich Western Stemmed Tradition assemblages spanning the LP/EH, providing a unique opportunity to address this issue. We present ongoing geoarchaeological research at each site and discuss both the macro- and microscopic characteristics that help define the YDCE. This paper presents one approach for disentangling human-environment dynamics occurring at the end of the Pleistocene in the Great Basin.

**[53] Teresa Matheson<sup>(1)</sup>, F. Rahemtulla<sup>(2)</sup>, F. Berna<sup>(1)</sup>**

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(2) Anthropology, University of Northern British Columbia, Prince George, Canada

#### **Investigating site formation processes at EjTa-4 on Calvert Island, British Columbia: results from a microstratigraphic study of excavation units 12 and 10/15**

*Keywords: site formation processes; microstratigraphy; soil micromorphology; FTIR; shell midden/matrix*

Accurate interpretation of the archaeological record depends largely on detailed reconstruction of site formation processes. The microscopic and chemical study of archaeological deposits (i.e., the microstratigraphic approach) is effective at reconstructing cultural and natural processes that occurred at any archaeological site. The focus of this investigation is to test the effectiveness of soil micromorphology and FTIR, two methodological pillars of the microstratigraphic approach, to study site formation processes at EjTa-4, a large shell-matrix site on the central coast of British Columbia. Results indicate well-preserved evidence for activities dating back to 3300 years ago, including built environments, and food processing in the forest. These findings contribute important new information to our knowledge of pre-contact Northwest Coast societies, and to deciphering large shell-matrix sites such as EjTa-4.

**[54] Don H. Butler<sup>(1)</sup>, B.A. Potter<sup>(2)</sup>, J.D. Reuther<sup>(3, 1)</sup>**

(1) Department of Anthropology, University of Alaska Fairbanks, Fairbanks, United States

(2) Arctic Studies Center, Liaocheng University, Liaocheng City, China

(3) Museum of the North, University of Alaska Fairbanks, Fairbanks, United States

### **Geoarchaeology of paleo-Critical Zones expressed in the Mead loess-paleosol sequence, Central Alaska**

*Keywords: Alaska; eastern Beringia; loess-paleosol sequence; critical zone science*

We outline progress on the geoarchaeological characterization of loess-paleosol sequences at the Mead (archaeological) and Camp (non-archaeological) sites as paleo-critical zone archives. The critical zone is the outermost veneer of Earth's surface where the lithosphere, atmosphere, and hydrosphere flux to make terrestrial life possible. Heterogeneity among these interactions, and in the local ecosystem services they foster, are often physicochemically integrated within paleosol substrates. Paleosols at archaeological sites may therefore provide much needed evidence for local environmental conditions that have direct bearing on forager behavioral adaptations. The Mead site provides a well-stratified loess-paleosol sequence useful for tracking scale-matched changes in local ecosystem services and forager settlement-subsistence strategies. To begin exploring how paleo-critical zones are expressed in this sequence, we focused on dating the two documented paleosol complexes and evaluating changes in pedogenic processes using a suite of geochemical, mineralogical, and botanical proxies. The deepest complex formed during the Bølling-Allerød (13,394 - 12,861 cal BP, 2σ), while the upper complex developed during the Younger Dryas through Early Holocene transition (12,656 - 10,866 cal BP, 2σ). The dominant signatures recorded in the Bølling-Allerød paleosol suggest that the Mead environ was a semi-arid herbaceous tundra dominated by grasses. This is suggested by weak paleosol formation, relatively low hydrolytic silicate weathering (Al/Al+Na and Ba/Sr), high salinization (K+Na/Al), the preservation of amorphous calcium carbonate and detrital smectite, low humic aromaticity, and a dominance of rondel, polylobate, and trapeziform morphotypes in the phytolith assemblage. The later Younger Dryas - Early Holocene paleosol is more mature, showing a greater degree of silicate weathering and calcite crystallinity, which suggests increasing moisture availability. We conclude with a discussion of hypotheses concerning the potential impacts a period of increased aridity may have impressed upon local habitats, specifically emphasizing pressures on wetland services and forager responses.

## Poster Sessions

Tuesday 18<sup>th</sup> and Wednesday 19<sup>th</sup> of May  
3pm

**[P.1] Opeyemi L. Adewumi<sup>(1, 2, 3, 4)</sup>, L. Oosterbeek<sup>(1, 3, 4)</sup>, M.Q. Ferreira<sup>(1, 2)</sup>, J.P. Vallverdú<sup>(5, 6)</sup>, N.J. Almeida<sup>(7)</sup>**

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(7) UNIARQ - Centro de Arqueologia da Universidade de Lisboa

### **Sequencing deposits and human occupations at the Early Neolithic site of Salvador (Abrantes, Portugal): preliminary micromorphological assessment.**

*Keywords: micromorphology; stratigraphic sequences; Iberia Peninsula; human activities; Tagus basin*

A preliminary micromorphological assessment of Salvador (Abrantes, Portugal) prehistoric site was undertaken in the context of the FCT funded project Moving Tasks Across Shapes (PTDC/EPH-ARQ/4356/2014). The main objective of the ongoing PhD project builds on those and aims to reassess the Holocene sequences of several sites in the middle Tagus basin, excavated and studied by IPT and ITM teams in the last 30 years. The micromorphological characterization of stratigraphies will allow us to refine relative chronologies, but a new comprehensive dating programme, planned as part of the CGEO strategic plan, will also be implemented.

A small area of 10 m<sup>2</sup> was excavated at Salvador resulting in Early Neolithic materials (industry and pottery), one possible combustion structure and negative features, which were preserved between recent agricultural ditches found throughout the area. The region where this site is situated suffers from slow sedimentation and high erosion rates, generating difficulties in the evaluation of stratigraphic sequences. This creates the need to study soil occupation and to analyse the main stratigraphic sequence through micromorphology, therefore contributing to questions of site formation processes and human adaptations to the environment. The major result of the preliminary micromorphological analysis based on the East profile indicated aeolian deposits which resulted from the re-sedimentation of sandy deposits by human impacts, such as the rapid agricultural expansion coeval with grazing and burning practices, and sheep/cattle drifts as evidenced from the Neolithic to Roman Age.

**[P.2] Phyllida Bailey<sup>(1)</sup>, M. Azzari<sup>(2)</sup>, I. Haynes<sup>(1)</sup>, P. Liverani<sup>(2)</sup>, C. Rosa<sup>(3)</sup>, L-M. Shillito<sup>(1)</sup>**

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### **The environmental impact of political, military and religious changes in the Eastern Caelian.**

*Keywords: ROMETRANS; georadar; ERT; GPR, archaeobotany*

ROMETRANS, the first project of its kind, aims to further our understanding of the religious, military and political transformation of the Eastern Caelian Hill from the 1st to 8th centuries C.E. During this

time the area went from being home to the extravagant quasi-rural horti, homes to elite families, through a period when it was dominated by imperial palaces and military bases, to becoming, with the building of the world's first cathedral and the palace of the Bishop of Rome, the centre of Catholic Christendom.

ROMETRANS integrates the study of 11 sub-surface excavated areas, the largest geo-radar and laser scanning surveys ever conducted in Rome, and an extensive programme of archival research to revolutionise our knowledge of this quarter. By incorporating archaeological, historical, topographical and geographical research, the project seeks to create a holistic 4D approach to the Eastern Caelian that goes beyond isolated studies of individual structures to understanding the evolving landscape as a whole.

Fundamental to this aim is consideration of how these changes manifested on the environment in terms of vegetation cover and land exploitation. This will be investigated through a combination of geophysical survey data, archival research, archaeobotanical and borehole analysis. Provisional archaeobotanical techniques include palynology and microcharcoal analysis with the likely addition of macro-remain identification and further micro-fossil analysis in the future depending on the nature of the deposits recovered.

This environmental investigation stands to not only significantly expand our knowledge of local and regional vegetation but will also synthesise existing data into an invaluable diachronic visualisation of the landscape in a key quarter of Imperial Rome during a time of unprecedented change that echoed throughout the Empire.

More information available at <https://research.ncl.ac.uk/rometrans/>

**[P.3] Alvise Barbieri<sup>(1)</sup>, M. Carvalho<sup>(1, 2)</sup>, P. Horta<sup>(1)</sup>, R. Matias<sup>(1)</sup>, D. Maio<sup>(1)</sup>, V. Aldeias<sup>(1, 3)</sup>, N. Bicho<sup>(1)</sup>, J. Cascalheira<sup>(1)</sup>**

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### **Tracing the primary context of Neanderthal occupations within a complex karst system – preliminary geoarchaeological results from Escoural (Alentejo, Southern Portugal).**

*Keywords: Neanderthals; Iberia; Escoural cave*

Escoural is the only cave with Palaeolithic rock art from Western Iberia and one of the very few caves with Palaeolithic occupations known from Southern Portugal. The site was intercepted and partly destroyed during quarrying activity in the mid-20<sup>th</sup> century. In the 1960s and 1990s, archaeological investigations led to the discovery of paintings, engravings and stone tools in a large chamber placed at the far back of the cave. In the Southern-East (SE) portion of Escoural, smaller cavities, accessible from the outside through multiple openings, were discovered. In them, excavations unearthed rich Middle Palaeolithic deposits, covered by a large rockfall and subsequent Neolithic burials. The excavators hypothesized that the Middle Palaeolithic artifacts were deposited by colluvial processes, which originated from outside the cave. Limited information was published about the site lithology, its archaeological assemblages and dating.

To achieve a better understanding of the formation of the Middle Palaeolithic deposits of Escoural, we re-investigated one of the SE cavities (P1) and the area outside its entrances (P2). We identified and expanded previous excavation areas and collected archaeological, faunal, anthracological and micromorphological materials, which are currently being studied. Our preliminary geoarchaeological data show that Middle Palaeolithic sediments in P1 and P2 resulted from the erosion of upslope areas

within the karst system (in the case of P1) and the above plateau (in the case of P2). The reworking of these materials was not a continuous process, but it alternated with periods of stability, during which increasing rate of dripping water and calcium carbonate precipitation formed thin (<5 cm thick) crusts (especially in P1). We conclude that at least some of the Middle Palaeolithic materials buried at P1 and P2 are in secondary position. Nevertheless, the possibility to isolate separate Neanderthal occupations at Escoural and reconstruct their relationship with past environments is not entirely precluded.

**[P.4] Stefano Costanzo<sup>(1)</sup>**

(1) Dipartimento Asia, Africa e Mediterraneo, Università degli Studi di Napoli "L'Orientale", Napoli, Italy

**Archaeological landscapes and Holocene records of climate changes in the Kassala Region (Eastern Sudan): kickstart research and future perspectives**

*Keywords: Sudan; Sahel; Holocene; climate changes; landscape archaeology*

When browsing the literature about Holocene African climate changes, the far eastern region of the sahelian belt seems to be under-represented, but new data are elucidating Holocene environmental dynamics that occurred in Eastern Sudan during the Holocene. This brief presentation aims at displaying the current state and future perspectives of the geoarchaeological research in the region. A recently published geomorphological map depicts the fossil fluvial plain and the vast foothill pediplain that characterize the regional landscape, whose evolution was driven by Quaternary climate shifts and micro-tectonics. The map lays the foundations for interpreting the plentiful archaeological evidence found therein. Kickstart investigations in the archaeological site of Mahal Teglinos – a small secluded valley encircled by bare-rock granite domes – spotlighted the existence of a Middle-Holocene organic soil buried beneath an archaeologically prosperous aeolian/colluvial deposit. Forthcoming results will shed light on more, newly explored foothill contexts, and upcoming field seasons are being planned to investigate the precise age and evolution of the fossil fluvial plain. These new insights will join the supra-regional mosaic of the Late Quaternary landscape evolution of North Africa, with special consideration to the interplay between changing environments and cultural landscapes. This work in progress started in the early '90s under the activities of the IAMSK - Italian Archaeological Mission to the Sudan Kassala and resumed in 2010 with the IAEES - Italian Archaeological Expedition to the Eastern Sudan (University of Naples "L'Orientale").

**[P.5] Ada Dinckal<sup>(1, 2)</sup>, E.C. Fisher<sup>(3, 4, 5)</sup>, A.I.R. Herries<sup>(1, 6)</sup>, C.W. Marean<sup>(3, 4)</sup>**

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**Mapping magnetism: geophysical modelling of stratigraphic features at Pinnacle Point 5-6 North, South Africa.**

*Keywords: magnetic susceptibility; anthropogenic deposits; digital models; Middle Stone Age; South Africa*

Our study introduces developments in utilising geostatistical modelling of magnetic susceptibility as a method of geophysical prospection of archaeological stratigraphy. This study was conducted at the Middle Stone Age rock shelter site of Pinnacle Point 5-6 North (PP5-6N). Our models are overlaid onto high-resolution photography of the stratigraphic sequence to study the lateral and

vertical changes within the magnetic signature of the archaeological sequence. *In situ* analysis is reinforced by methods of laboratory magnetic mineralogical analysis; Magnetic Susceptibility; Frequency Dependent Susceptibility (FD $\chi$ ); Isothermal Remanence Magnetisation (IRM); and Anhyseric Remanence Magnetisation (ARM); to understand the composition of the magnetic minerals creating the *in situ* signature. This study shows that there is consistent variation in the magnetic signatures of the sequence which can be mapped with *in situ* MS which can in turn provide insight into changes of human behaviour.

**[P.6] Francesca Glanville-Wallis<sup>(1)</sup>, M. Arroyo-Kalin<sup>(1)</sup>**

(1) Institute of Archaeology, University College London, London, United Kingdom

### **Amazonian Dark Earths: comparison based on enrichment factors and geo-accumulation indices**

*Keywords: Amazonian Dark Earths; geochemistry; geoarchaeology*

Amazonian Dark Earths (ADEs) are both archaeological records of past human activities and markers of their impact. Geochemical data from these soils provide both chemical indicators of activities and a measure of the impact of these activities on soil chemistry. The aim of this presentation is to compare the influence of Pre-Columbian populations on the chemical soil properties of Amazonian Dark Earths (ADE) in Central and Eastern Amazonia. Enrichment Factors (EF) and Geo-accumulation Indices (I<sub>geo</sub>) were calculated using geochemical data from ADEs collected from the existing literature, which were also examined using Principal Component Analysis (PCA) to identify chemical elements associated with human activity. Results confirmed that soil chemistry varies greatly between sites but also suggest that derived measures of enrichment and accumulation offer promising approximations to undertake geochemical comparison among ADE sites forming in different contexts.

**[P.7] Daniela de Matos<sup>(1)</sup>, C.E. Miller<sup>(1, 2, 3)</sup>**

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### **Site formation processes at Leba Cave, Southwest Angola.**

*Keywords: micromorphology; site formation processes; Stone Age; Leba Cave; Angola*

Leba Cave is a site located at the dolomite quarry of the Humpata Plateau, Huíla Highlands. Geographically positioned at the westernmost transect of the Great Escarpment of Southern Africa, connecting the hyper-arid Namib desert and the woodlands of the Central plateau in the east, this sector of the escarpment hosts one of the largest freshwater aquifers in southwestern Africa and a mosaic of environments known for its rich but under-studied biodiversity and culture. For paleoanthropological studies, this subtropical area represents a challenge due to its high rates of decay, bioturbation and erosion which do not provide suitable context for preservation of organic material.

Past mining activities uncovered a series of fossil-bearing infillings in caves and fissures of the highland region, yielding biostratigraphic evidence from the early Pleistocene to the present. Inside Leba Cave, a sequence of cultural remains suggests human presence since the Middle Stone Age. Current fieldwork indicates a complex depositional history correlated with anthropogenic and biogenic activity, along with geogenic processes specific to the Leba karst and its hydrological regime. This study is focused on the stratigraphic reassessment of the cave infillings, identification of depositional agents, post- and syndepositional phenomena occurring at Leba. Preliminary results are



based on the micromorphological analysis of samples collected from different excavations inside the cave, between 2018 and 2019. Ultimately, this information will be used to establish a site formation model coupled with geochronological and isotopic data.

**[P.8] Sarah Ann Meinekat<sup>(1, 2)</sup>, C.E. Miller<sup>(1, 2, 3)</sup>, K. Rademaker<sup>(4)</sup>**

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### **Micro-contextual analysis of Terminal Pleistocene and Early Holocene living space and anthropogenic features in Quebrada Jaguay-280, Peru.**

*Keywords: micromorphology; terminal Pleistocene; Early Holocene; Peru*

Quebrada Jaguay-280 (QJ-280) is a well-known Terminal Pleistocene site situated at the southern Peruvian Pacific coast, in the northern tail of the hyper-arid Atacama Desert. QJ-280 is a key site to help better understand early settlement processes in the South American continent and migration routes. It was first extensively excavated by Dan Sandweiss in the 1990s. Our team excavated the site in 2017 in order to improve the chronology, illuminate its relation to early highland sites, and understand the site's formation.

Here, we present results from the geoarchaeological investigation of QJ-280, combining high-resolution micro-contextual analyses and GIS data. This approach allows us to understand, visualize, and contextualize features. We were able to identify house floors, combustion features, and pit features, which represent some of the earliest evidence for domestic structures in South America.

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### **Application of the QuEChERS analytical method to the analysis of real samples from a Neanderthal site.**

*Keywords: alkanes; archaeology; biomarkers; lipids; extraction protocols*

An analytical extraction method has been recently developed for the analysis of n-alkanes (lipid biomarkers) in sedimentary contexts [1]. This method was based on the original and versatile QuEChERS (standing for Quick, Easy, Cheap, Effective, Rugged, and Safe) method proposed by Anastassiades et al [2]. That procedure has been applied to a wide range of analytes from matrices of different nature and provides higher recoveries and better analytical performance than the extraction procedures used up to now for sediment analysis. Here, we assess QuEChERS-extracted n-alkane yields in four archaeological sediment samples from El Salt Middle Palaeolithic site and compare the results with those obtained for the same samples extracted by ultrasound-assisted extraction (a protocol typically employed with this aim). Statistical tests indicate that both methods show similar extraction efficiency. Thus, our results corroborate the effectiveness of the QuEChERS method for the n-alkane extraction from sediment samples.

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### **A pedological approach to the study of buried soils as a contribution to the climatic and human-induced erosion activity; La Terrasse, Bibracte oppidum.**

*Keywords: anthropogenic; archaeology; deposits; oppidum; soil development*

The perception of long-term environmental modifications under natural and anthropogenic conditions is a way to deal with future human sustainability. One of the most important factors is the variation of the climate influencing the soil cover along pedogenesis. Human activities influence not only variations in plant species composition and vegetation cover, but also the microclimate and soil cover itself through the feedback mechanisms. The area of La Terrasse is located at one part of the Celtic oppidum Bibracte. This site indicates the presence of the large embedded settlements known as oppida. The frost weathered geological substrate is more recumbent to erosion. But due to this erosion, pedogenic processes worked weakly. After the encircling rampart construction, the landscape was relatively maintained, and the natural or anthropogenic erosion processes terminated. Multiproxy studies of deposits in trenches forming beyond different parts of the surrounding area and excavated during the 2019 period exposed complicated archives of the soil formations, being influenced by erosion and anthropogenic factors. The recent most noticeable anthropogenic influence on the La Terrasse area is caused by the construction of ramparts. The traces of a former soil or occupational surface are detectable mainly geochemically. The archaeological soils described by the overburden did not expose any notable geochemical signal characteristic of accelerated use, despite its location in the most proper and permanent area of the section. It is clear that before the start of the Neolithic, the soils of La Terrasse were frequently eroded, probably due to natural processes, vulnerability to the presence of frost-weathered subsoil. The geochemical signal of the currently formed archaeological soil is not typical for long term use because the material of that soil was accumulated promptly from the areas with relatively weak human impact.

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### **Integrating geoarchaeological techniques to reveal the invisible stratigraphy at Umhlatuzana rockshelter, South Africa - a grid-based approach.**

*Keywords: site formation processes; integrating geoarchaeology; geochemistry; sediment mixing; taphonomy*

Umhlatuzana rockshelter is an archaeological site with an occupational record spanning the last ~70,000 years, covering the Middle Stone Age (MSA), Later Stone Age (LSA), and Iron Age. The deposits bearing Pleistocene archaeological assemblages at Umhlatuzana rockshelter appear homogeneous with no macroscopically visible stratigraphic boundaries. This means the integrity of the archaeological assemblages is difficult to ascertain. Moreover, the sedimentation rate, taphonomic history, and the environmental context across the sequence are unclear. This study aims to resolve these issues by integrating different geoarchaeological techniques in order to explore fine-resolution geochemical differentiations of the sediments that are macroscopically invisible. Samples were systematically retrieved from the western profile of the site following a grid-based sampling strategy and analysed for pH, elemental composition (XRF), and Magnetic Susceptibility. These methods were chosen because they provide insight into 'invisible' geoarchaeological dynamics, related to sediment input (geogenic and anthropogenic), taphonomy, and environmental conditions. Additionally, the results were integrated with preliminary micromorphological observations. Our study reveals a gradual change in the geochemistry of the deposits throughout the Pleistocene, related to a combination of environmental change and occupation intensity. Furthermore, the gradual change within the geochemical data indicates that no large-scale sediment mixing took place (contrary to previous suggestions), while small-scale mixing related to bioturbation is visible in the micromorphological thin sections. Our study offers a successful multi-proxy approach to systematically sample and analyse archaeological deposits at the macro and micro scale, integrating a variety of geoarchaeological techniques. The approach provides insight into the depositional and post-depositional history of the site, and allows questions of stratigraphic integrity, anthropogenic input, preservation, and environmental change to be addressed.

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### **Reconstructing the Holocene palaeoenvironmental evolution of Corsican coastal wetlands based on palaeobiological proxies.**

*Keywords: geoarchaeology; western Mediterranean; palynology; Holocene; Corsican wetlands*

The interest of reconstructing the palaeoenvironmental evolution during the Holocene lies in the interaction between climatic oscillations and a substantial increase in anthropogenic impact following the adoption of the farming practices since the Neolithic. In the case of coastal areas,

additional interest is placed in the palaeoenvironmental impact of the sea level rise during the Holocene in relation to global warming. Although palynological research mainly provides data on a regional basis, strictly local data can also be obtained, based on the analysis of short-dispersal pollen taxa and non-pollen palynomorphs (NPP), to study the evolution of local environments. This study is focused on the reconstruction of palaeoenvironmental evolution of coastal wetlands of Corsica (France) during the Holocene. Multiple cores along the Island have been studied integrating interdisciplinary palaeobiological proxies (pollen, non-pollen palynomorphs and malacology). In this paper, we discuss the role of palynological analysis in the study of the evolution of local environmental conditions. The identification of aquatic plants, freshwater algae, cyanobacteria and other aquatic organisms provided detailed information about limnological conditions, salinity, tropism and depth of waters; while other microremains informed about other processes such as soil erosion episodes and animal frequentation of coastal wetlands. This study has shown a general trend to the transition from marine environments to freshwater lagoons during the Middle Holocene and from lagoons to brackish swamps and marshlands during the Late Holocene, playing a significant role the cooling climate events in 4200, 2800 and 500 cal BP. Finally, evidence of human impact is attested since Neolithic (ca. 7400 cal BP) and increased exponentially from the Iron Age onwards.

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#### **Raise it up and wash it all away: micromorphological and sedimentological analysis of pre-colonial raised fields from Grand Macoua and Savanna Bod, French Guiana**

*Keywords: raised fields; French Guiana; Amazonia; agriculture; pre-Columbian*

Raised fields on the Guianese coast were built within seasonally flooded savannas with research indicating that this resilient agricultural system supported large, highly-organised populations until the European contact. Yet, there are many unanswered questions about the construction, functioning, and abandonment of these features. Although raised fields in French Guiana have been investigated through multi-disciplinary projects, geoarchaeology has not been utilised to its full potential, as it has been in Llanos de Moxos (SW Amazonia). This pilot study consisted of a geoarchaeological analysis from two raised field sites, Grand Macoua and Savanna Bois Diable, employing soil micromorphology and bulk soil analysis. The aims of this project were to a) investigate the construction, functioning, and post-depositional processes affecting raised fields in French Guiana, b) to illustrate the importance of geoarchaeology in the general study of these types of landscapes. The study identified microscopic evidence that is consistent with a lateral drainage purpose and with soil nutrient improvement at Savanna Bois Diable. It also refined our understanding of the stratigraphy of Savanna Bois Diable fields, potentially identifying construction phasing. Lastly, the study identified clear compositional differences (phosphates, microcharcoal, organic matter) between the two sites. These results highlight the need to understand the long history of raised fields in the Guianas in order to attain informed interpretations and also offer suggestions for conservation.

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### **A micro-contextual approach to pyrotechnologies of Middle and Later Stone Age foragers in central Africa. Presenting the new MicroAsh project.**

*Keywords: anthropogenic deposits; Malawi; rockshelters*

The production and control of fire is a significant technological development and one that is unique to humans. However, the ways in which early pyrotechnology evolved and varied amongst prehistoric foragers are still poorly resolved. The main objective of the MicroAsh project is to reconstruct Middle and Later Stone Age (MSA and LSA) pyrotechnology variability by focusing on three granitic rockshelters located in the Kasitu Valley in northern Malawi: Hora-1, Kadawonda-1, and Mazinga-1. Human remains have been retrieved from all three sites, with the apparent use of fire for ritual interment practices during the LSA. Ashes form the bulk of the sedimentary components, enabling the exceptional preservation of anthropogenic organic materials in these granitic settings. Notwithstanding, individual combustion features are rarely recognizable in the field. MicroAsh will use high resolution geoarchaeological techniques, including micromorphology and  $\mu$ FTIR, to study (1) site formation processes, (2) the relationship between fire use and paleoenvironment, (3) variability in the use of fire for ritual and subsistence practices through time, and (4) site-use intensity. By exploring different techniques to study these human-made fire residues, we hope to contribute to a better understanding of pyrotechnologies during the MSA and LSA, and related aspects of human behavior, such as rituals and foraging strategies.

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### **Invisible floors – Investigating domestic occupation surfaces at Olynthos through micromorphology and multi-elemental geochemistry.**

*Keywords: micromorphology; floors; multi-elemental geochemistry; use of space; Classical Greece*

The identification of occupation surfaces is essential to understand how space was organized and used. For various reasons, these may not be revealed on the macro-scale which requires looking beyond the visible archaeological remains. Here, geoarchaeology holds a range of techniques to investigate traces of past human activity and site formation processes on the micro-scale.

Integrated within the wider research design, the Olynthos Project uses geoarchaeology to study the organisation and use of domestic space in Northern Greece. Given its outstanding preservation, Olynthos is known for its orthogonal settlement layout and the pastas house, an archetype for Classical domestic architecture, providing one of the best examples for a Classical Greek city. One of the houses, Bix6, has recently been subject to intensive excavation and (geo)archaeological study aiming to understand how different rooms were used.

At Olynthos, the identification of occupation surfaces in the field is challenging as most floors are assumed to be made of earthen materials similar to the fill of decayed mudbricks. Even though some rooms reveal plastered surfaces, the identification of floors based on architectural features and artefacts is problematic which also complicates the interpretation of use of space.

The combination of soil micromorphology and multi-elemental geochemistry not only enables the identification of floors but also provides significant insights into their make-up and degradation processes. Preliminary results show significant differences between the archaeological sediments and

the local soil. Deposits in House Bix6 are enriched in calcium suggesting an anthropogenic source and may indicate use of calcium-rich material in the construction of occupation surfaces.

As one of the firsts, the case study outlines the potential of geoarchaeological approaches for the investigation of Classical domestic space that in combination with archaeological data allow reconstructing detailed life histories of buildings at Olynthos.

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**The SEArch project: Investigating the ‘Blue Economy’ of Prehistoric Europe with microarchaeological approaches**

*Keywords: Neolithic transition; shell middens; Iberia; coastal adaptation*

Marine resources played a crucial role for coastal Mesolithic societies of Atlantic Europe, paving the way to sedentism and complex societal behaviour. Although coastal shell middens of Neolithic age are identified, it is currently unclear if these sites relate to coastal adaptations by the first farming communities or reflect the resilience of former forager coastal populations. Shell middens are, therefore, a key-element for understanding the Neolithization process and the nature of the first contacts between Mesolithic and Neolithic populations in western Europe. The SEArch project focuses on the role of human coastal adaptations and environmental changes in coastal ecosystems in the process of the Neolithic expansion, using a geoarchaeological approach at the microscopic and molecular scale. The methodology combines micromorphology, lipid biomarkers and compound-specific isotope analyses. The main research objectives are: 1) understanding shell middens formation processes; 2) identify the use of aquatic plants and seaweeds; 3) reconstruction marine resources harvesting and processing; and 4) paleoecological reconstruction of intertidal coastal ecosystems.

Finally, inquiring about the contacts between local Mesolithic and pioneer Neolithic populations and potentiate our ancient connection to the sea to foster preservation of coastal ecosystems are major aims of the project.

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**Preliminary data on hunting strategies of Paleolithic people in central Mongolia**

*Keywords: strontium; Rare Earth Elements; bone; sediment*

The chronology and dynamics of the Pleistocene human occupation of various geographical regions depended on several factors including migrations of human populations and their interactions with autochthonous settlers, climatic conditions and environmental productivity, routes of migrating ungulate prey, and the availability of high-quality lithic raw material. These factors determined the character of regional exploitation as continuous or sporadic occupational episodes. Mongolia is a key region for understanding Late Pleistocene human dispersals. The multilayered 33-18 ka Moiltyn-am

site, situated in the Orkhon River valley in central Mongolia's Khangai Mountains, is preliminarily thought to be the result of short-term episodic occupations. Here, Upper Paleolithic assemblages indicate that human activity was associated with a workshop for knapping pebbles collected from local alluvium.

To understand where and in what ways local populations hunted large game, we analyzed the Rare Earth Elements (REE) and Strontium (Sr) isotopic composition of animal bones and related sediments from Moiltyn-am. The Sr isotopic composition of animal bones is the product of the last habitat occupied and this parameter allows reconstruction of animals' migration patterns. The analysis of REE composition revealed that bone samples from Moiltyn-am Layers 3 and 4 (36-38 ka) were fossilized without the taphonomic impact of soil formation processes. The Strontium isotopic composition of those samples ranged from 0.70973 to 0.70983, while the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of sediment samples from those same strata varied from 0.70938 to 0.70959. Statistical analysis reveals these ranges are close, indicating that animals were procured within short distances from the Moiltyn-am site. This study was principally supported by the Russian Scientific Foundation, Project № 19-78-10112, and the Je Tsongkhapa Endowment for Central and Inner Asian Archaeology, University of Arizona.

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#### **Stratigraphy and formation processes of the Pleistocene deposit at Balzi Rossi Museo site (Italy).**

*Keywords: Late Pleistocene; Middle-Upper Palaeolithic; Balzi Rossi; geoarchaeology; soil and sediment micromorphology*

Situated in Liguria, near the border between Italy and France, the archaeological area of Balzi Rossi counts at least twelve archaeological sites which preserve sedimentary successions dated from the Middle Pleistocene to the Holocene – mostly in caves and rock shelters. Despite their international relevance, the successions are poorly studied from a geoarchaeological point of view. We here focus on the Balzi Rossi Museo site, also known as Ex Birreria. It is a Pleistocene open-air site, which records the Last Glacial-Interglacial cycle, from the MIS 5 to the beginning of the Holocene and yielded both Middle and Upper Palaeolithic deposits. Fieldwork was performed in the 1990s, but information on site stratigraphy and chronology remain incomplete. This contribution aims at filling this lack of information, providing new data on site formation, through the geoarchaeological investigation of the succession, the revision of published data and micromorphological observation. The results provide additional data on microstratigraphic evidence and post-depositional processes, which allow us to confirm the previous reconstruction of the site succession. The stratigraphic layout and the sedimentary characteristics indicate three sedimentary facies, from bottom to top: a paleosoil, formed onto a last interglacial marine abrasion surface, a thick set of stratified breccias, and debris material affected by soil formation. Major discontinuities are observed between them, mostly indicating abrupt changes in climatic conditions. Sediment accumulation results from dynamics related to karstic and slope processes, opposed to periods of surface stabilization. Post-depositional processes include diagenesis and weathering dynamics that have selectively affected archaeological components, as well as secondary accumulation and bioturbation. We here discuss the results of the geoarchaeological study of the site, to obtain a better understanding of the stratigraphic framework of the Balzi Rossi complex, a key-context for the Middle-Upper Paleolithic transition in northwestern Italy.