CONFERENCE BOOKLET

United Kingdom Archaeological Science 2019
Manchester, UK

24th – 26th April: Manchester Institute of Biotechnology

The University of Manchester
For the first time since its beginning, 32 years ago, UKAS comes to Manchester – a vibrant and diverse city, a university with a rich history and a world-leader in pioneering, interdisciplinary and collaborative research, and the home of one of the first ancient DNA laboratories in the UK.

UKAS is the largest archaeological science focussed conference in the UK and this year we are welcoming you to a varied scientific programme at The Manchester Institute of Biotechnology, as well as our social events at the Manchester Museum and on campus throughout this three-day conference.

The University of Manchester’s reputation for world-renowned science firsts began when Ernest Rutherford split the atom. The spirit of discovery and innovation was continued with the invention of the world’s first stored-program computer and such daring projects as the Lovell Telescope at the Jodrell Bank Observatory.

Archaeology is an important facet of Manchester’s identity. The University is an internationally recognised centre for social archaeology and works closely with Manchester Museum, the UK’s leading university museum with globally renowned collections spanning from prehistory right up to the 21st century. To reflect this, the Manchester Centre for Archaeology and Egyptology was launched in September 2018.

In Manchester you can explore everything from natural history and the environment to science, technology and the culture, including collections of one of the most famous early practitioners of cave archaeology and former curator at the Manchester Museum, Sir William Boyd-Dawkins, noted for his research on fossils and the antiquity of humans.
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We are grateful to the following sponsors and exhibitors for supporting UKAS 2019:

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ANTIQUITY
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VENUE INFORMATION:

24th – 26th April: Manchester Institute of Biotechnology

All daytime conference proceedings will take place in the Manchester Institute of Biotechnology, which is located in the John Garside Building (Building 16 on Campus Map). Oral presentations will take place in the lecture theatre on the mezzanine level, outside which will be the registration desk, social space, and Poster sessions. Lunch and coffee breaks will also be held in this open area.
The wine reception will take place on the first evening of the conference (24th April) within the fossil gallery at the Manchester Museum (Building 44 on Campus Map). This can be found on the Ground Floor next to the Museum Shop (enter via the Main Entrance on Coupland Street).

Should you require further directions or have any questions, please look out for the UKAS committee and volunteers, who can be identified by their black UKAS t-shirts and/or purple lanyards, and will be happy to help.
INFORMATION FOR DELEGATES PRESENTING:

24\textsuperscript{th} – 26\textsuperscript{th} April: Manchester Institute of Biotechnology

Podium Presentations

Each podium slot will last for 20 minutes. Oral talks are expected to be 15 minutes, with 5 minutes for questions.

Poster Presentations

The poster boards are best suited for portrait A1 size posters (594 x 841 mm). Presenters for odd numbered posters are expected to be present at their posters for the Thursday lunchtime slot, whereas even numbered poster presenters are expected to be by their posters on the Friday lunchtime slot.

Poster can be displayed from the morning of the day of presentation; that is, from 9am on Thursday for odd numbered posters, and from 9am on Friday for even numbered posters.
Student and Early Career Researcher PRIZES:

24th – 26th April: Manchester Institute of Biotechnology

Thanks to the support of Antiquity, the Journal of Archaeological Science and Historic England, we are able to offer four prizes:

The Antiquity Best Student Oral Presentation Prize (£200)

The Antiquity Best Student Poster Presentation Prize (£200)

The Journal of Archaeological Science Early Career Researcher Prize (£250)

The Historic England Greatest Impact on Cultural Resource Management Prize (£100)
CONFERENCE SCHEDULE:

24th – 26th April: Manchester Institute of Biotechnology

WEDNESDAY 24th APRIL

10:00  Registration and Coffee

10:30  Opening Remarks

10:40  Palaeoclimate and Environmental Change 1 (Chair: Buckley)

12:20 – 13:20  Lunch
12:30 – 13:00  Antiquity Publication Workshop for Early Career Researchers

13:20  Palaeoclimate and Environmental Change 2 (Chair: Buckley)

15:00 – 15:30  Coffee

15:30  Post-Domestication Adaptations (Chair: Stallibrass)

Evening Event:

19:00  Manchester Museum Wine Reception (Fossil Gallery)
THURSDAY 25\textsuperscript{th} APRIL

09:10  \hspace{1em} \textbf{Diet and Subsistence 1} (Chair: Berg)

10:50 – 11:20  \hspace{1em} Coffee

11:20  \hspace{1em} \textbf{Diet and Subsistence 2} (Chair: Berg)

12:40 – 13:40  \hspace{1em} Lunch & Poster Session 1 (odd numbered posters)

13:40 – 14:20  \hspace{1em} Plenary Lecture by Prof. Richard Evershed

14:20  \hspace{1em} \textbf{Biomolecular Archaeology 1} (Chair: Brown)

15:00 – 15:30  \hspace{1em} Coffee

15:30  \hspace{1em} \textbf{Biomolecular Archaeology 2} (Chair: Brown)

\textbf{Evening Events:}

18:30 – 19:00  \hspace{1em} Andrew Davison presenting on ‘Temperance Buildings in Manchester and the North West’
(Talk)
\hspace{1em} to be held at \textbf{Beer Nouveau Microbrewery}

20:00 – 21:30  \hspace{1em} \textbf{Campus Tour} with the Browns
FRIDAY 26th APRIL

09:10  Mobility and Migrations (Chair: Chamberlain)

10:30 – 11:00  Coffee

11:00  Imaging and Chemical Analysis in Archaeology 1 (Chair: Sellers)

12:20 – 13:20  Lunch & Poster Session 2 (even numbered posters)

13:20  Imaging and Chemical Analysis in Archaeology 2 (Chair: Sellers)

14:40 – 15:00  Coffee

15:00  Biological Anthropology (Chair: Chamberlain)

16:40  Concluding Remarks and Prizes

Social Event:

19:00  Conference Dinner in Christie’s Bistro
PODIUM PRESENTATION SCHEDULE:

24th – 26th April: Manchester Institute of Biotechnology

WEDNESDAY 24th APRIL

10:00 Registration and Coffee
10:30 Opening Remarks

Palaeoclimate and Environmental Change 1
10:40 Rhiannon Stevens – UP North: Colonisation, Cultural Diversification and Climate Change after the Last Glacial Maximum
11:00 Sarah Pederzani – Using Isotope Zooarchaeology to Reconstruct Late Pleistocene Climate and Seasonality: New Evidence from La Ferrassie, France
11:20 Kate Britton – Shifting Baselines: Exploring Plasticity in Herbivore Dietary Ecology in Late Pleistocene France using Stable Isotope Analysis
11:40 Jennifer Jones – Adaptability, Resilience and Environmental Buffering during the Late Pleistocene in Northern Spain: A Biomolecular Approach
12:00 Seren Griffiths – Events and Processes: The Importance of Competing Analytical Scales in Palaeoenvironmental and Geochronological Analysis. Holocene Case Studies from the Republic of Ireland and the United Kingdom

12:20 – 13:20 Lunch

Palaeoclimate and Environmental Change 2
13:20 Elizabeth Stroud – Early Medieval Agriculture: Exploring Evidence for Open Field Systems
13:40 Michell House – Exploring Cattle Management and Procurement at Great Zimbabwe (AD 1200 – 1700) using Stable Isotope Analysis
14:00 Emma Loftus – Stable Isotope Investigations of Later Stone Age Shellfishing and Local Climate Change on the South African West Coast
14:20 Ayusha Nayak – Tales of Resilience: Stable Isotope Approaches to Cultural Change and Dietary Reconstructions in South Asia
14:40 Gundula Müldner – Putting SW England on the (Sr Isotope) Map: Insights from the Exeter: A Place in Time Project

15:00 – 15:30 Coffee
Post-Domestication Adaptations

15:30  Loïc Harrault – Animal Domestication in the High Arctic: Integrated Science and Ethnography Applied to the Interpretation of Yarte VI on the Yamal Peninsula, Northwest Siberia
15:50  Andrew Hare – The Origin and Spread of Sheep using Ancient DNA
16:10  Michael Wallace – Going Beyond Barley: Adaptations and Importation of Barley Varieties in Northern Scotland
16:30  Michael Scott – Whole Genome Sequence from 3000-year-old Egyptian Emmer Wheat Reveals Dispersal and Domestication History

Evening Event:

18:00 – 20:00  Manchester Museum Wine Reception (Fossil Gallery)

THURSDAY 25th APRIL

Diet and Subsistence 1

09:10  Simon Hammann – Investigating Intra-Site Dietary Variations at the Romano-British Defence Fort of Vindolanda
09:30  Caitlin Greenwood – Dairying in the Roman Cirencester Hinterland
09:50  Alice Ughi – Investigating Revolution or Transition in Agriculture, Animal Husbandry and Human Diet in Medieval Sicily: A Stable Isotope Approach
10:10  Alison Harris – Accessing the Childhood Diets of Bering Sea Coast Hunter-Gatherers through Carbon Isotope Analysis of Dental Collagen Amino Acids
10:30  Vaughan Grimes - … and (no) thanks for all the fish! Diet Reconstruction in Medieval to Post-Medieval Belgium using Carbon Isotope Analysis of Bone Collagen Amino Acids
10:50 – 11:20  Coffee

Diet and Subsistence 2

11:20  Orsolya Czére – Ploughing the Waves: Reconstructing Urban Dietscapes in Medieval Maritime Scotland
11:40  Emma Lightfoot – Isotopic Variation in Foxtail Millet (Setaria) with Variety and Watering Regime
12:00  Jack Dury – Consideration of Freshwater and Multiple Marine Reservoir Effects: Dating of Individuals with Mixed Diets from Northern Sweden
12:20 Lisa Lodwick – Agricultural Economies at Roman Villas: Isotopic and Archaeobotanical Evidence for Changes in Cereal Production Strategies in Iron Age and Roman Britain

12:40 – 13:40 Lunch & Poster Session 1 (odd numbered posters)

13:40 – 14:20 Plenary Lecture by Prof. Richard Evershed
The Foundations of Dairying and Lactase Persistence in Prehistoric Europe

Biomolecular Archaeology 1
14:40 Abigail Ramsøe – DeamiDATE 1.0: Site-Specific Deamidation as a Tool to Assess Authenticity of Members of Ancient Proteomes

15:00 – 15:30 Coffee

Biomolecular Archaeology 2
15:30 Carla Soto Quintana – Archival Proteins: Parchment Manufacturing and Its Effects on Collagen Degradation
15:50 Ashley Coutu – The Shipwreck in a Diamond Mine
16:10 Sam Leggett – Why We Should ‘Play’ More with Stable Isotope Data: An Adventure in Multivariate Statistics and Anglo-Saxon Teeth
16:30 Angela Lamb – Simultaneous δ¹³C, δ¹⁵N and δ³⁴S Analysis of 1mg of Bone Collagen: Analytical Improvements

Evening Events:
18:30 – 19:00 Andrew Davison presentation on ‘Temperance Buildings in Manchester and the North West’ at Beer Nouveau microbrewery
20:00 – 21:30 Campus tour with the Browns

FRIDAY 26th APRIL

Mobility and Migrations
09:10 Shevan Wilkin – Pastoralism and Agriculture on the Ancient Eastern Eurasian Steppe through Multi-Proxy Archaeological Data Sets
09:30 Alcántara Fors – Keeping Tabs on Cattle Mobility through Geometric Morphometrics, Finite-Element Analysis and Cross-Sectional Properties
09:50 Judith Muñoz Sogas – Travelling Amphorae and Thirsty Seafarers at the Temple of Kommos
10:10 Christopher Snoeck – Stonehenge Rising from the Ashes

10:30 – 11:00 Coffee

**Imaging and Chemical Analysis in Archaeology 1**

11:00 Kate Fulcher – Molecular Analysis of Ritual Black Liquids Applied to Ancient Egyptian Coffins
11:20 Ki Suk Park – Application of Image Analysis for the Identification of the Ceramic Pottery Production Technologies of the North Caucasus (Russia) in the Bronze/Iron Age
11:40 Barbara Veselka – Debunking the Dentine: Micro-CT and Histological Assessment of a Mineralisation Defect in Teeth Attributed to Vitamin D Deficiency in two 17th – 19th Century Dutch Communities
12:00 Patrick Randolph – Quinney – Application of Advanced Tomographic Imagining to Understand the Origin and Evolution of Human Cancer: Issues of Quantitative Histopathology, Homology and Clinical Validation

12:20 – 13:20 Lunch & Poster Session 2 (even numbered posters)

**Imaging and Chemical Analysis in Archaeology 2**

13:20 Jennifer Wakefield – Looted Ancient Egyptian Tomb: Mummy Restoration in Ancient Times
13:40 Yali Yun – Scientific Analysis of Metal Objects and Glass Unearthed from the Han Zunian Tomb of the Norther Qi Dynasty (550 AD – 577 AD), China
14:00 Helen Whelton – Faecal Biomarker Analysis of Coprolites as a Means of Investigating the Nature and Timing of the Earliest Human Occupation of North America
14:20 Jessica Munkittrick – Exploring Sources of Lead in Children during Colonial Settlement of Northeastern North America during the 18th and 19th Centuries

14:40 – 15:00 Coffee

**Biological Anthropology**

15:00 Richard Madgwick – Mortuary Practices in Iron Age South West England: A Multi-Scalar Approach
15:20 Sina White – Survival Comparative of a Medieval Hospital and Lay Cemeteries
15:40 Eleanor Joan Green – London through the Ages: A Genetic Investigation of the Thames Skull Collection
16:00  Yaowu Hu – Osteobiography of a Potter near the Oupan Kiln, Anhui, China during the Early Tang Dynasty (544 – 644 cal. AD) by Osteological and Multistable Isotopes Approach

16:20  Lara Cassidy – The Genomics of Megaliths: Exploring Social Structure in Irish Neolithic Civilization through Ancient DNA Analysis

16:40  **Concluding Remarks and Prizes**

**Social Event:**

18:30  Conference Dinner at Christie’s Bistro
LIST OF POSTER PRESENTATIONS:

24\textsuperscript{th} – 26\textsuperscript{th} April: Manchester Institute of Biotechnology

1. **Michell House, S. Chirikure and Judith Sealy:**
   Comparing Stable Carbon Isotopes of Tooth Dentine and Enamel: Evidence for Dietary Routing in Cattle?

2. **Eric J. Guiry, Thomas C.A. Royle, and R.G. Matson:**
   Anadromy and the Archaeological Record: Exploring Stable Carbon Isotope Records for Ancient Aquatic Resource Use.

3. **Iwona Kozieradzka-Ogunmakin:**
   Humans and Their Environment in the Past: Using Stable Isotopes to Investigate the Collapse of the Kushite Kingdom of Meroe (300 BC – AD 350), Sudan.

4. **Mael Le Corre, Joshua Wright, Vaughan Grimes, Steeve D. Côté, and Kate Britton:**
   PleistoHERD: Linking Intra-Tooth Isotope Profiles and Isoscapes to Reconstruct Prey-Species Palaeomigrations using Computational Modelling.

5. **Rhys Williams, Tim Thompson, Caroline Orr, Andrew Birley, Gillian Taylor:**
   3D Imaging for Visualising Roman Activity at Vindolanda.

6. **Alice Rose, Sarah Inskip, Mary Price, Tamsin O’Connell, John Robb:**
   Diet in English Medieval Hospitals: A Stable Isotope Study.

7. **Kevin Salesse, Christophe SNOECK, Rica ANNAERT, Mathieu BOUDIN, Giacomo CAPUZZO, Sarah DALLE, Guy DE MULDER, Marta HLAD, Ioannis KONTOPOULOS, Charlotte SABAUX, Amanda SENGELØV,**
Elisavet STAMATAKI, Dries TYS, Barbara VESELKA, Eugène WARMENBOL, Martine VERCAUTEREN:

Dressed to be Burnt: Experimental Approach To Detect the Presence of Garments Worn by the Deceased through Stable Isotope Analysis ($\delta^{13}C$, $\delta^{18}O$).

8. Tessi Loeffelmann, Philippe Claeys, Janet Montgomery, Julian D Richards, Sarah Semple, Christophe Snoeck:

Mobility at Heath Wood Viking Cremation Cemetery, Ingleby, Derbyshire: The Isotopic Evidence.

9. M. Cemre Ustunkaya, Nathan Wright, R. N. Singh, Cameron A. Petrie:

At the Fringe of Indus Civilisation: What Can We Tell About Indus People at Khanak, Lohari Ragho I and Masudpur I through Macro-Botanical Remains.

10. Sina White:

Survival Comparative of a Medieval Hospital and Lay Cemeteries.

11. Emily Tilby:

Zooarchaeological Analysis of the Micromammal Remains from the Middle and Upper Palaeolithic Deposits of Shanidar Cave (Iraqi Kurdistan).

12. Aurore Monnereau, Martin Carver, Alessandra Molinari, Nathan Wales:

Ancient Genomic Analysis of Multi-Faith Populations from Medieval Sicily.


Tracing the Domestication History of the Common Sunflower using Ancient DNA.
14. **Hrafnhildur Helga Halldórsdóttir, Dr. Gillian Taylor, Dr. Andrew Birley, Dr. Elizabeth Greene:**

Soil Interactions and Collagen Preservation in Leather Artefacts from Vindolanda, Northumberland.

15. **Bryony Rogers, Vanessa Pashley, Matt Horstwood, Geoff Nowell, Jane Evans and Janet Montgomery:**

Reassessing Calibration of LA-MC-ICP-MS Sr Isotope Analysis of Low Strontium Tooth Enamel.

16. **Elisavet Stamataki Marta Hlad, Christophe Snoeck, Rica Annaert, Mathieu Boudin, Giacomo Capuzzo, Sarah Dalle, Guy De Mulder, Ioannis Kontopoulos, Charlotte Sabaux, Kevin Salesse, Amanda Sengeløy, Barbara Veselka, Eugène Warmenbol, Martine Vercauteren, Dries Tys:**

Osteoarchaeological Analysis of Cremated Human Remains from Belgium.

17. **Amanda Sengeløy, Christophe Snoeck, Rica Annaert, Mathieu Boudin, Giacomo Cappuzzo, Sarah Dalle, Guy De Mulder, Marta Hlad, Ioannis Kontopoulos, Charlotte Sabaux, Kevin Salesse, Elisavet Stamataki, Dries Tys, Barbara Veselka, Eugène Warmenbol, Martine Vercauteren:**

Variation in Bioavailable $^{87}Sr/^{86}Sr$ of Plant Samples in a Small Urban Wooded Area.

18. **Fiona Skinner, Louise Martin and Rhiannon Stevens:**

Investigating the Impact of Faunal Biodiversity on Late Neanderthal and Early Modern Human Behaviour in Britain.

19. **Tingting Wang, Benjamin T. Fuller, Dong Wei, Hongen Jiang, Wenying Li, Yaowu Hu:**

Iso-Biography of the Iron Age Mummied Yingpan Man from the Lop Nor Region of Xinjiang, China.
20. Sarah Dalle, Christophe Snoeck, Rica Annaert, Mathieu Boudin, Giacomo Capuzzo, Marta Hlad, Ioannis Kontopoulous, Charlotte Sabaux, Kevin Salesse, Amanda Sengeløy, Elisavet Stamataki, Dries Tys, Martine Vercauteren, Barbara Veselka, Eugène Warmenbol, Guy De Mulder:

   The Study of Mobility in Belgium through the Interpretation of the Burial Landscape and Strontium Isotope Analysis.

21. Sarah Delaney, Michelle Alexander, Anita Radini:

   Exploring the Potential for Dental Calculus to Reveal New Evidence for Medieval Lifeways.

22. Carrie Wright, Paul Northrup, E. Troy Rasbury:

   ArChTES: An Investigation of Dental Enamel Mineralisation Combining Spectromicroscopy and Isotopic Analysis.

23. Gillian Taylor, Heather Hopkins Pepper, Aboli Vavle, Katrin Kania:

   Micromorphological of Textiles Fibres from Experimental Dyeing Vats.

24. Jacob Ieuan Griffith:

   A Discussion on Major Zooarchaeological Frameworks used to Quantify Animal Remains: Evaluating Quantifications Impact on the Interpretation of Faunal Datasets.

25. Riia Chmielowski and Kamal Badreshany:

   Characterisation of Swedish Steatite via LA-ICP-MS, XRD and SEM.

26. Vanessa Reid:

   Geoarchaeological Approaches to Pictish Settlement Sites: Assessing Heritage at Risk.
27. Alessandro Ceccarelli P. Quinn, R.N. Singh, C.A. Petrie:
   From Rural Production to Relational Landscapes: A Technological Reassessment of Indus Ceramics from NW India.

28. Rachel Winter, Arkley Bandeira, Rafael Brandi, Thiago Fossile, Silvia Soncin, Matthew Von Tersch, André Carlo Colonese:
   Stable Isotope Evidence for Pre-Columbian Diet in the Amazon Coast of Brazil.
Sercon are dedicated to the design, manufacture and support of Isotope Ratio Mass Spectrometers and their associated sample preparation systems.

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PODIUM PRESENTATION ABSTRACTS:

24\textsuperscript{th} – 26\textsuperscript{th} April: Manchester Institute of Biotechnology
During the harshest conditions of the last ice age European human populations abandoned northern latitudes, with their range contracting to southern refugia. By the time ice sheets retreated and large areas of land became available for resettlement there had been a hiatus of several thousand years. The ERC funded UP-North project is examining the relationship between climate change and the recolonisation of Northern Europe after the last glacial maximum. As people move eastwards and northwards to colonise uninhabited landscapes, increasing diversification is seen in their stone and bone tool industries. UP-North is exploring the relationship between this human dispersal, cultural development, prey ecology and climate change. Here we present the results of this multiproxy study, which is creating an integrated chronological, palaeoclimatic and palaeoecological frameworks that is directly linked to the Late and Final Palaeolithic archaeological record in the British Isles, Belgium, Germany, Czech Republic, Switzerland and Poland. New radiocarbon dates from a suite of Late and Final Palaeolithic sites show previous chronologies need revising. Stable isotope analyses (C, N, S, O, Sr) of hunted fauna (reindeer, horse, bovids and red deer) and human bones and teeth are providing new palaeoenvironmental and palaeodietary reconstructions that are directly linked to the archaeological evidence, thus allowing the relationship between cultural and climate change to be explored.
PALAEOCLIMATE AND ENVIRONMENTAL CHANGE

Using Isotope Zooarchaeology to Reconstruct Late Pleistocene Climate and Seasonality: New Evidence from La Ferrassie, France

Sarah Pederzani 1,2, Vera Aldeias, Paul Goldberg, Jean-Jacques Hublin, Stéphane Madelain, Shannon McPherron, Dennis Sandgathe, Teresa E. Steele, Alain Turq, Kate Britton

1 Department of Human Evolution, Max-Planck-Institute for Evolutionary Anthropology, Leipzig, Germany
2 Department of Archaeology, University of Aberdeen, Aberdeen, United Kingdom

Climatic reconstruction is central to Palaeolithic Archaeology and the study of past human lifeways. At middle and high latitudes, the consideration of seasonal climatic conditions and temperatures is particularly important as a means of better understanding human-environment inter-actions and hominin adaptations. However, despite this pivotal role in contextualizing the archaeological evidence of hominin evolution, palaeotemperature data is often derived from broad regional or global scale proxies, which lack a site-specific scale of resolution; palaeoseasonality data itself is often scarce. Climatic information gleaned from oxygen isotopic analyses of faunal remains provides an opportunity to gain insights into seasonal temperature cycles on a smaller, more local level that, significantly, can be linked directly to archaeological contexts.

Here we present high resolution seasonal climate data for Neanderthal activity at the site of La Ferrassie, southwest France, obtained from oxygen isotope analyses of sequential enamel samples from herbivore teeth from Layers 2, 5A and 5B. Exploiting the direct relationship between faunal remains and hominin activity at the site, we explore changes in palaeoclimate and palaeoseasonality during MIS3 and MIS4 across multiple levels of occupation. The isotope data document changes in environmental conditions, influencing not only average conditions but also summer and winter climatic extremes. Using the new isotope data, we investigate the relationship between environmental change, site use, and faunal resource exploitation at La Ferrassie. We explore the challenges and opportunities of combining high-resolution isotope data with other site-specific environmental indicators, such as faunal spectrum and micromorphological data, along with broader climatic models.
Shifting Baselines: Exploring Plasticity in Herbivore Dietary Ecology in Late Pleistocene France Using Stable Isotope Analysis

Kate Britton 1, Elodie-Laure Jimenez, Mael le Corre, Joshua Wright, Vaughan Grimes, Steeve D. Côté, Sylvain Renou, Wil Rendu, Mike Richards, Jean Jacques-Hublin and Marie Soressi

1Department of Archaeology, University of Aberdeen, Scotland, United Kingdom

The isotope analyses of archaeo-faunal assemblages have significant, but largely unrealised, potential for gaining new palaeoecological insights into the long-term adaptability and resilience of mid- and large-sized herbivores. This is particularly the case for certain species, such as reindeer (Rangifer), which are intermediate feeders and can also exploit food resources with characteristic isotope ratios (i.e. lichens) that most herbivores cannot when other plants are scarce due to environmental conditions or competition.

As part of the PleistoHERD project, we present here a targeted diachronic study of herbivore dietary ecology from the late Middle and Upper Palaeolithic site of Les Cottés using the stable isotope analysis of bone collagen. Spanning a 10,000-year period from the late Mousterian to early Aurignacian, the abundant remains of diverse fauna from this well-dated site represent an excellent opportunity to investigate and characterise herbivore dietary ecology in late Pleistocene France. Data reveal niche partitioning amongst the late Pleistocene herbivore communities of Les Cottés, with Rangifer exhibiting consistently elevated △13C values relative to horses and bovids, which is likely a consequence of lichen consumption. However, data from Rangifer (and to an extent Bos/Bison) deviate from the shifting isotopic ‘baseline’ of exclusively-grazing species to varying extents, highlighting plasticity in the behaviour of these intermediate-feeding genera through time. The implications for future studies are explored.
Adaptability, Resilience and Environmental Buffering during the Late Pleistocene in Northern Spain: A Biomolecular Approach

Jennifer R. Jones, Ana B. Marin Arroyo, Michael Richards

1Department of Archaeology, University of Aberdeen, Scotland, United Kingdom

The pleniglacial refugium of the Cantabrian region was intensively occupied by human and animal populations from the Last Glacial Maximum onwards. Why this region was so important during this time is currently not well understood. Characterising what the environment was like on a local level is crucial in understanding the archaeological importance of the region, and how human and animal populations were able to survive, and indeed thrive even during these times. Bone collagen $\delta^{13}$C and $\delta^{15}$N analysis of the most commonly consumed herbivores (red deer and Spanish ibex) from hunted ungulates was used to explore localised environmental conditions when humans occupied key sites in the region, with evidence of long chronologies. Isotopic results were correlated with other environmental proxies to explore how climatic shifts affected animal ecologies, in relation to environmental change.

Results show that during the peak of the LGM, ibex were able to adapt their niches to survive, and were a major prey species for human hunters during this time. Changes in environment reflected in the long archaeological sequences analysed show that, despite fluctuating conditions, animals and humans had the flexibility and resilience to adapt and survive. The diverse environmental opportunities offered in the high-relief of the mountains in this area, framed by the coast may explain the “popularity” of the Cantabrian Region throughout the Late Upper Palaeolithic and Mesolithic, as reflected in the increasing numbers of archaeological sites during this time. This study highlights the importance of using biomolecular techniques to understand Palaeolithic environments and predator-prey ecologies.
Events and Processes: The Importance of Competing Analytical Scales in Palaeoenvironmental and Geochronological Analysis. Holocene Case Studies from the Republic of Ireland and the United Kingdom

Seren Griffiths ¹ and Ben Gearey ²

¹School of Forensic and Applied Sciences, University of Central Lancashire, United Kingdom

²Department of Archaeology, University College Cork, Republic of Ireland

This presentation will use recent case studies from 4th-1st millennium cal BC Britain and Ireland to discuss the importance of foundation concepts of ‘events’ and ‘processes’ in palaeoenvironmental and geochronological analysis. We will include case studies from the ‘elm decline’, sea level change, and bog surface wetness indicators to discuss how palaeoenvironmental events are conceived by palaeoenvironmental, geochronological and archaeological specialists. We will discuss how these concepts and competing evidence from multi-proxy palaeoenvironmental indicators are integrated into models of causality and overarching archaeological narratives. We will suggest that despite increasingly sophisticated chronological modelling, proxy identification, and precise analytical scales workers often do not match these with sufficiently nuanced narrative frameworks. We move beyond these case studies to address how wider-ranging discussions in Quaternary science about the definition of analytical scale, and the science technology context of palaeoenvironmental work can impact on narrative outcomes.
Early Medieval Agriculture: Exploring Evidence for Open Field Systems

Elizabeth Stroud 1, Amy Bogaard, Michael Charles, Emily Forster, Matilda Homes, Mark McKerracher, Samantha Neil, Christopher Ramsey, Richard Thomas, and Helena Hamerow

1 School of Archaeology, University of Oxford, United Kingdom

During the 8th to 13th centuries a major expansion in arable farming, in particular cereal production, occurred in parts of England and Europe, developing into open field agriculture. The detection of open fields via a number of proxies is being attempted using case study sites around England, and in Germany, to help pinpoint when, where and how this ‘cerealisation’ occurred.

This presentation will explore for the first time the possibilities of detecting crop husbandry regimes shifts though stable carbon and nitrogen crop isotopes, complemented by functional weed ecology, pollen, livestock pathologies, and settlement data. Three key innovations allowed for the dramatic increase in cereal production during the early medieval period: three-field crop rotation, the spread of the mouldboard plough and the extensification of cultivation. Stable carbon and nitrogen isotopes from crop remain provide information on arable soil conditions, allowing inferences regarding the ‘compatability’ of crops potentially grown in rotation. Such evidence is complemented by functional weed ecology which provides an indication of the intensity of cultivation (soil fertility and mechanical disturbance). Evidence of cattle pathologies pertaining to traction and specifically the pulling of heavier ploughs, as well as palynological evidence of the expansion of arable farming, can also provide evidence for the introduction of the heavier mouldboard plough and expansion on to clay soils. Using case studies from England and Germany, this integrated methodology will be tested to understand where, when and if the introduction of a different farming regime occurred.
Exploring Cattle Management and Procurement at Great Zimbabwe (AD 1200 – 1700) Using Stable Isotope Analysis

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Great Zimbabwe was the centre of an ancient Shona state from AD1200- 1700. It is known for its magnificent architecture and involvement in long-distance (inter-continental) trade. In this society, cattle were of vital social, economic and political importance. The distribution of cattle remains across the site has been relatively well researched, as have aspects of the cattle morphology. However, herd management strategies have never been explored using empirical evidence, although researchers have proposed seasonal transhumance between upland and lowland regions. This talk presents the results of a PhD project that measures δ18O, δ13C, δ15N and 87Sr/86Sr in serial samples of cattle tooth enamel and dentine. The 87Sr/86Sr and δ18O values show that most cattle consumed at Great Zimbabwe were raised (at least for the first year of life) in the lowveld at least 45 km south of the site. Today, this area is infested with tsetse fly (which causes sleeping sickness), making it less attractive to cattle herders. There is no evidence for seasonal transhumance. δ13C profiles show heterogeneous dietary patterns in early life, probably reflecting animals drawn from herds pastured in environmentally diverse regions. We now seek to integrate this new information with previous studies of the distribution of Zimbabwe pattern ceramics and other material culture. This work contributes to our understanding of the flow of key resources within the Zimbabwe state, refining relationships between sites and regions.
Stable Isotope Investigations of Later Stone Age Shellfishing and Local Climate Changes on the South African West Coast

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Coastal hunter-gatherer occupation of southern African shores spans tens of thousands of years and has accumulated valuable repositories of seasonal climate and human behavioural data, in the form of archaeological shell-middens. High-resolution stable isotope analyses of marine shells provide seasonally resolved records of sea surface temperatures and upwelling, and allow reconstruction of the annual scheduling of shellfishing activities and coastal occupation. We present a modern calibration study of the limpet Cymbula granatina, demonstrating the utility of this species for palaeoclimate and seasonality studies. We also investigate the appropriate scale of sampling for this relatively fast-growing species, given the temporal span and research questions. Regional shifts in sea surface temperatures and upwelling are reconstructed from several radiocarbon-dated sites across the Holocene, and correlated with shifts in the cultural record from the region. We examine the scheduling of hunter-gatherer shellfishing, including from both rockshelter and open-air “megamidden” contexts, and demonstrate a persistent pattern of winter shellfish harvesting, similar to that observed along the southern coast during the Holocene Later Stone Age, in spite of marked ecological differences between the regions.
Tales of Resilience: Stable Isotope Approaches to Cultural Change and Dietary Reconstructions in South Asia

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South Asia, today, is a mosaic of densely populated, but ecologically, linguistically and culturally distinct, zones. This diversity can be attributed to both human migrations into the region from the Late Pleistocene, as well as the movement of ideas and economies. Notably, the beginnings of agriculture in the region serve as an impetus towards increasing cultural complexity, intercultural interactions, and intensive land use. Moreover, owing to its geographical location, South Asia has held significance as a ‘crossroads’ between Eurasia and Africa. Archaeobotanical records show the arrival of diverse crops such as wheat and barley from Southwest Asia or of millets from East Asia and Africa from the mid-Holocene. However, the nature of their incorporation into subsistence strategies, whether as direct, dietary reliance or as domesticate fodder, remains to be fully understood. This is significant not only in terms of revealing past diets, but also to elucidate the farming strategies deployed and the extent of land use for different crop species. While stable isotope analysis of archaeological remains is widely used to address such questions in other parts of the world, there exists a significant literature gap for South Asia. Here, we apply the techniques to human and faunal remains from three micro-regions (the Deccan Plateau, Northern India, and the Swat Valley), spanning a timescale from the 3rd millennium BC to the 15th century, in order to address the outlined research gaps. Our results demonstrate changing subsistence strategies as a result of new adaptations and inter-cultural interactions in some areas, while others show resilience despite interactions and climatic disruptions. We argue that our datasets allow us to link subsistence to changes and differentiation in social organisation and wider environmental factors. This multi-scalar, multi-proxy, and cross-temporal study helps shed light on the region’s trajectory to the cultural hyperdiversity that characterises it today.
Putting SW England on the (Sr Isotope) Map: Insights from the Exeter: A Place in Time Project

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Compared to most other European countries, the biosphere Sr isotope values in the UK are usually regarded as well-mapped out, although the uneven distribution of available biosphere samples means that some major regions are still poorly characterised. This is especially true for SW England (Devon and Cornwall), where the few previously existing $^{87}\text{Sr}/^{86}\text{Sr}$ measurements suggest much less radiogenic biosphere values than might be expected based on the geological substrate. The large data-set generated for the “Exeter: A Place in Time Project”, which investigates changes in meat supply to the city of Exeter from the 1st to the 15th centuries AD by multi-isotope analysis, now allows a substantial revision of this picture. Our paper presents $^{87}\text{Sr}/^{86}\text{Sr}$ data of modern plants, and archaeological and modern fauna which demonstrate that parts of SW England must be considered when discussing potential origins of individuals with strontium isotope values >0.714 in Britain. We will give an overview of the new results and discuss our current understanding of spatial constraints and complexities.
Animal Domestication in the High Arctic: Integrated Science and Ethnography Applied to the Interpretation of Yarte VI on the Yamal Peninsula, Northwest Siberia

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The history of animal domestication in the Arctic is typically represented as being marginal, or a weak copy of more complex pastoral situations in southern regions. For example, reindeer have been characterized as being “deficiently” domesticated, or in “an early stage” of domestication. This paper tests these assumptions by presenting the results of a detailed investigation of the iconic archaeological site of IArte 6 on the IAMal Peninsula, northwest Siberia, for markers of early Rangifer and dog taming and the rise of transport reindeer husbandry in the first millennium AD. We used an integrated suite of environmental archaeology methods, including portable and lab-based geoarchaeological techniques, faecal lipid biomarkers, zooarchaeology, archaeobotany, and palynology, as well as a nuanced understanding of Rangifer ethology, to test three ethnoarchaeological models for interpreting IArte 6: as the campsite of a herd-following group, a decoy-mediated hunting group, or a transport reindeer husbandry group. Our results demonstrate that IArte 6, thought by some to be a hearth of Arctic domestication, was in fact the home of several different types of complex relations between humans and reindeer, and sometimes dog, and that these relations stretched from the ⁵th to the ¹²th century AD, a much longer period of time than had previously been assumed. Using dendroclimatological records, we also propose that the beginnings of transport reindeer husbandry may have been linked to marked climate change. These results prompt a reconsideration of the standard models of how to understand reindeer pastoralism. We argue for a renewed attention to how Rangifer are held and enticed into a long-term relationship with people and suggest that canine domestication may have also been key to this relationship. These complex human-animal relations are reflected in the landscape and can be reconstructed through the use of an appropriate suite of archaeological science methods.
POST-DOMESTICATION ADAPTATIONS

The Origin and Spread of Sheep Using Ancient DNA

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Sheep being one of the first animals to be involved in agriculture, they are ideal candidates for using ancient DNA to understand the mechanics of animal domestication and the subsequent spread of the species. Originating from Mouflon in Western Asia and spreading across Europe as far as the British Isles along with other forms of agriculture, in this talk I will present genetic data from a range of contexts, from the Neolithic to Medieval period. Genetic changes associated with the initial domestication will be looked at, such as the changes in genetic variation between pre and post domestication. The data presented will also be from a wide geographical region, spanning from Europe to Western Asia. This allows for an examination of the spread of the species, as this form of agriculture moves across Eurasia. Further genetic changes are associated with this migration, such as observed decreases in genetic diversity.

Time permitting, I will also shift focus past the Neolithic to Bronze Age samples and beyond. The spread of sheep does not appear to be one directional, and increased movement and trade bring with it more changes. It has been proposed that the initial wave of sheep brought to Europe is later replaced, likely during the Bronze Age. A possible explanation for this would be the advent of a new type of technology, making wool a viable product. Further investigation into this is ongoing.
Going Beyond Barley: Adaptation and Importation of Barley Varieties to Northern Scotland

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The spread of agriculture relied on crops adapting to newly encountered environments that differed greatly from those under which they were originally domesticated. These adaptations involved the emergence of an array of locally-adapted crop varieties: landraces. Following the development of a geometric morphometric approach to the recognition of different landraces from charred barley grains (Wallace et al 2018), in this talk we will present results of morphometric analysis of barley grains from prehistoric and historic sites in northern Scotland. Particular focus will be on Orkney and Shetland, where island-adapted varieties were (and continue to be) important for sustainable agriculture. By tracing the morphometric signature of different landraces in the archaeobotanical record it is possible to chart the appearance of distinctive landraces and begins to explore the driving forces behind crop changes.
Whole Genome Sequence from 3000-year-old Egyptian Emmer Wheat Reveals Dispersal and Domestication History

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We present the first whole genome sequence data from an ancient wheat: an Egyptian emmer wheat collected from the Hememiah North Spur archaeological site in the 1920s and AMS radiocarbon dated to the Late Ramesside period, Dyn 20, 1130 – 1000 cal. BCE. Genome-wide relatedness with modern landraces connects the initial arrival of cereal agriculture across the Iranian Plateau and into the Indus valley by 8000 years ago with the arrival of emmer wheat into the Egyptian Nile Valley around 6500 years ago. Emmer dispersal into Egypt appears to be largely distinct from northward and westward emmer dispersals from the fertile crescent. Furthermore, the sequenced ancient Egyptian specimen shows evidence of introgressions from wild emmer wheats currently found in the Southern Levant. These genetic contributions probably occurred during emmer wheat cultivation in the Southern Levant and prior to its introduction to Egypt, demonstrating relatively diverse and ongoing gene flow from wild crop relatives into domesticated wheats. The genetic data also suggests that this specimen shares its history of selection on key domestication traits with that of all modern domesticated emmer landraces, consistent with archaeological evidence. In particular, we find haplotypes shared with modern domesticated emmers at loci underlying shattering, seed dormancy, and seed size. Finally, we find that the ancient Egyptian specimen has a relatively unique genotype. It is likely that ongoing selection on crop improvement and the extirpation of emmer wheat from Egypt mean that genetic diversity present in emmer wheat cultivated in ancient Egypt has been lost and cannot be found among modern landraces.
Investigating Intra-Site Dietary Variations at the Romano-British Defence Fort of Vindolanda

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Vindolanda is the site of a Roman defence fort south of Hadrian’s Wall. The fort was occupied in different phases from ca 85 – 400 CE, and the site itself until the 9th century. Excavations since the 1930s have unearthed a very rich collection of archaeological finds. The anoxic burial conditions allow for excellent preservation of organic material such as leather, textiles and even wooden writing tablets. The world-renowned Vindolanda Tablets list (among much other information) storage and shopping items, offering, together with existing archaeobotanical and archaeozoological data, a window into the diets of the Roman soldiers. Recently we also detected alkylresorcinols and phytosterols, biomarkers for cereal processing, in the absorbed residues from a small number of ceramic samples from Vindolanda (Hammann and Cramp, 2018, Journal of Archaeological Science 93). However, these existing data did not allow distinction of diets between different groups within the fort, e.g. common infantry soldiers and commanding officers, which through their higher status might have had access to different food classes. To investigate this, we analysed a further 140 ceramic sherds (AD105 – 120) for their preserved lipids using GC, GC-Q/TOF MS and GC-C-IRMS. The sherds derived from contexts associated with common soldiers, higher-rank officers and the local, non-army population. Lipids were solvent-extracted and recovered in interpretable quantities from 80% of samples. Plant lipids were frequently detected through the presence of wax esters, long-chain alcohols and plant sterols. Finally, GC-C-IRMS analysis of 16:0 and 18:0 fatty acids showed that vessels associated with groups inhabiting the fort were largely used to process a mixture of ruminant and non-ruminant adipose tissue (i.e. cattle/sheep/goat and pig). In contrast, the pottery associated with the local population outside the fort showed stable isotope signatures consistent with a mixture of ruminant adipose and dairy fats, suggesting differing dietary or culinary patterns were practiced.
This paper presents new isotope data to discuss dairying as subsistence strategy in Roman Britain. Dairying was an important component of diet in Britain during much of prehistory (Copley et al 2005a, 2005b, 2005c) but, on the basis of zooarchaeology, is considered much less important during the Roman period (e.g. Hesse 2011). This paper presents direct evidence for dairying and other use of animal products derived from Organic Residue Analysis (ORA) of ceramics from Roman Britain. The data derives from my PhD, a regional study of diet in the Roman Cirencester hinterland. A variety of different Romano-British site types are considered, including the major town of Cirencester, several villas, small towns and rural settlements, spanning the Late Iron Age through to the end of the 4th century. I conclude that while dairying practices decreased in importance during the Roman period, dairy products contributed significantly to the diet at rural sites even by the 4th century AD. I argue this change is caused by increasing extensification of agricultural practice, which sees the relatively more labour-intensive dairying practices replaced by less intensive farming methods.
DIET AND SUBSISTENCE

Investigating Revolution or Transition in Agriculture, Animal Husbandry and Human Diet in Medieval Sicily: A Stable Isotope Approach

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During the medieval period, society in Sicily was subject to successive changes in socio-political and religious power (Byzantine, Arab, Norman, Swabian). For this research, which forms part of the collaborative ERC funded project SICTRANSIT, dietary evidence from carbon ($\delta^{13}$C) and nitrogen ($\delta^{15}$N) stable isotope analysis is explored with the aim of enhancing our current understanding of the hypothesised social, economic, and demographic changes that took place alongside these shifting ruling powers.

This presentation presents the bulk isotopic analysis of $\delta^{13}$C and $\delta^{15}$N of human (n=157) and animal (n=94) bone collagen and charred plant remains (n=15), from 15 sites used to examine the diets of medieval (4th-13th century AD) multi-faith populations from Sicily. Patterning between and within sites related to burial practice or period (Byzantine/Arab/Norman) are emerging. The possibility of new crops such as sorghum and sugarcane (C$_4$) entering the diet during Arab rule is investigated with reference to the hypothesised increase in C$_4$ consumption seen in certain areas of Spain during a similar period.

These bulk carbon and nitrogen analyses of bone collagen are also combined with analysis of $\delta^{13}$C of bone carbonate (potential to detect C$_4$ sugarcane) and $\delta^{13}$C and $\delta^{15}$N isotopic analysis of individual amino acids of collagen (via GC-C-IRMS) to explore dietary routing and better characterise dietary components in selected individuals. The presentation will include some of these preliminary analyses.
Accessing the Childhood Diets of Bering Sea Coast Hunter-Gatherers through Carbon Isotope Analysis of Dental Collagen Amino Acids

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Ancestral to modern Inuit and Yupik populations, the Old Bering Sea (OBS) culture (1500-1000 BP), was one of the earliest fully marine-adapted cultures of the Bering Sea coast. The artistic and technological traditions of the OBS have received considerable study, but as with many Arctic cultures, the lives of women and children have received less scholarly attention. By combining recently developed methods in dentine serial sampling with compound-specific carbon isotope analysis of collagen amino acids (AAs), we investigate childhood diets in the far north, and explore the economic strategies employed by the OBS. We sectioned the first molars, which form during the first ten years in life, of six adults from the archaeological site of Ekven, on the Chukchi Peninsula. After measuring the bulk carbon (\( ^{13} \text{C} \)) and nitrogen isotope ratios of each incremental sample, selected dentine samples were derivatised and analysed by GC-C-IRMS to determine the AA \( ^{13} \text{C} \) values. We applied multivariate statistical analyses to identify patterns in the essential and non-essential AA \( ^{13} \text{C} \) values. The \( ^{13} \text{C} \) values of the non-essential AA glycine underwent marked increases after birth and appeared to track the consumption of breastmilk and the later introduction of supplementary foods. We noted significant inter- and intra-individual differences in the \( ^{13} \text{C} \) values of two essential AAs, valine and lysine. These data suggest that the while OBS subsistence was oriented around marine resources, it included seasonal or yearly changes in the species targeted. Through the novel use of \( ^{13} \text{C} \) analysis of AAs in dentine serial sections, our study provides a detailed analysis of past subsistence and childhood dietary practices of a population that lived north of the Arctic Circle.
DIET AND SUBSISTENCE

… and (no) thanks for all the fish! Diet Reconstruction in Medieval to Post-Medieval
Belgium Using Carbon Isotope Analysis of Bone Collagen Amino Acids

Vaughan Grimes¹, Madeleine Mant, Ben Fuller, Katrien Van de Vijver, Anton Ervynck, Geert Van Biesen, and Wim Van Neer

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There is considerable zooarchaeological and documented historical evidence indicating a shift in
human dietary patterns during the Medieval to Post-Medieval periods in Belgium. In particular,
from the 10th century AD onwards studies of archaeological faunal assemblages from inland
Belgian sites clearly show an initial focus on freshwater fish species, with a transition to marine
fish species that peak in the 17th-18th centuries AD. Counter to this evidence, however, carbon
and nitrogen stable isotope analyses on human bulk collagen during this time period does not
suggest fish, either freshwater or marine, played a significant role in their subsistence. To address
this dietary evidence conundrum, and to determine if bulk collagen isotope analyses has failed to
pick up a subtle aquatic food resource signal, we conducted a pilot study on 10th – 18th century
humans (n=33) and fauna (n=33) to explore the potential for carbon isotope analyses of amino
acids (¹³C_{\text{AA}}) to detect these elusive fish so apparent in the archaeological assemblages of
Medieval Belgium. Our results appear mostly congruous with the bulk isotope data, in that all
levels of society through time continued to source their dietary protein primarily from terrestrial
resources, despite fish being ubiquitous and readily available for consumption. We will discuss
the ¹³C_{\text{AA}} data in relation to similar studies involving Medieval to post-Medieval populations in
Europe and offer suggestions for the disparity seen between these direct (isotope-based) and in-
direct (zooarchaeological) dietary proxies.
Ploughing the Waves: Reconstructing Urban Dietscapes in Medieval Maritime Scotland

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Between the 9th and 11th centuries AD, an increase in marine fishing and marine fish consumption is evident in the archaeological record throughout Northern and Western Europe – the so-called ‘marine fish event horizon’. The rapid development of market based economies and the new requirements of growing populations in developing urban centres likely fuelled this expansion and new dietary habits, not least in Scotland where the North Sea fishing and commodities trade went on to have a profound economic, demographic and social impact on the local population. The first half of the second millennium was also characterised by an increase in population mobility, the growing importance of the Church, and the appearance of the first royal burghs in Scotland.

Building on decades of archaeological excavations in Aberdeen, Perth and Edinburgh, in this study we use stable isotope approaches to investigate dietary variability in high medieval urban centres in maritime Scotland during this transformative period, particularly with regards to the consumption of marine fish. Incorporating the analysis of close to 300 skeletons from 11 sites, alongside contemporary faunal remains, we explore the foodscapes and ‘dietscapes’ of Scotland’s emerging cities, drawing on abundant archaeological and historical evidence. Our results attest to the strong influence of socio-cultural status, and particularly of religion, on diet in Scottish Medieval urban centres. Differences between the inhabitants of the cities also suggest geographical (latitudinal) variation between the Scottish populations, and between Scottish and English populations, that cannot be satisfactorily explained by socio-demographic differentiation alone. The effect of broader environmental influences, including isotopic ‘baselines’, on the human dietary data from Medieval Britain is explored.
Isotopic Variation in Foxtail Millet (Setaria) with Variety and Watering Regime

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Isotopic palaeodietary studies generally focus on bone collagen. While plant remains are analysed, it is well known that plant isotope values can vary as a result of numerous factors, including soil conditions, the environment and type of plant. The millets were important food crops in prehistoric Eurasia, yet little is known about the isotopic differences within millet species. This paper presents the results from two growth experiments investigating isotopic variation in Setaria italica with landrace and watering regime. In the first experiment, we find significant isotopic variability within single leaves and panicles, and between leaves and panicles within the same plant, which must be considered when undertaking plant isotope studies. We find that the leaves and grains from the different accessions have a c. 2‰ range in □¹³C values, while the nitrogen isotope values in the grains have a c. 6‰ range. We also find an average offset of 0.9‰ between leaves and grains in □¹³C value. In the second experiment, we grew four replicates of twelve of these accessions and subjected them to different watering regimes. Contrary to the expectation that C₄ plants are relatively unaffected by environmental parameters, we found significant phenotypic and isotopic variation. The variation found is large enough to have archaeological implications, and within- and between-plant isotope variability should be considered in isotope studies. The range in □¹⁵N values in the first experiment is particularly significant as it is larger than the typical values quoted for a trophic level enrichment, and as such may lead to erroneous interpretations of the amount of animal protein in human or animal diets. It is therefore necessary to account for the variability in plant stable isotope values during palaeodietary reconstructions. The differences found with watering regime suggest that it is difficult to use C₄ plants in environmental reconstruction.
DIET AND SUBSISTENCE

Consideration of Freshwater and Multiple Marine Reservoir Effects: Dating of Individuals with Mixed Diets from Northern Sweden

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Human burials from the cemetery at the Rounala church, Northern Sweden, were radiocarbon dated to shed light on the use of the cemetery. Carbon, nitrogen and sulfur stable isotope analysis of bone collagen from 19 distinct individuals indicated that these individuals had a mixed diet consisting of freshwater, marine and terrestrial resources. Dietary modelling using FRUITS was employed to calculate the contributions of the different resources for each individual. These data were then used to calculate individual ΔR values, taking into account freshwater and multiple marine reservoir effects, the latter caused by Baltic and Atlantic marine dietary inputs, respectively. Radiocarbons dating of tissues from modern freshwater fish species demonstrate a lack of a freshwater reservoir effect in the area. Two OxCal models were used to provide endpoint age estimates. The calibrated data suggest that the site’s cemetery was most likely in use already from the 14th century, and perhaps until at least the late 18th century.
Agricultural Economies at Roman Villas: Isotopic and Archaeobotanical Evidence for Changes in Cereal Production Strategies in Iron Age and Roman Britain

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The Roman empire witnessed unprecedented demographic and economic growth in the early centuries AD. However, the ways in which agricultural systems changed to feed the burgeoning urban and military populations are unclear. Research within classical archaeology has focussed upon olive and wine production, whilst studies of arable farming within classical archaeology have presented models of intensifying agriculture, with limited examination of what this entails for crop husbandry practices, and socio-economic relations. Recent large-scale analysis of farming settlements in Roman Britain has indicated broad shifts in crop and animal choice but has provided limited specific insights as to systems of crop-husbandry. The measurement of δ¹³C and δ¹⁵N values in charred cereal grains provides insights on water status and the manuring of cereals but has so-far received limited applications in the Roman period. This paper will present results of isotopic analysis on charred cereal grains (barley, emmer, spelt) from Iron Age and Roman sites in Britain. Two case-studies are presented here. 1) From the Danebury environs study region in Hampshire, samples have been analysed from a hillfort (Danebury), Late Iron Age farmsteads (Nettlebank Copse and Suddern Farm), and two Roman villas (Dunkirt Barn and Grateley). 2) From a long-term occupation of a single settlement at Stanwick, East Midlands, where an Iron Age farmstead developed into a nucleated Roman settlement and then Roman villa. The isotopic results will be combined with traditional archaeobotanical evidence for crop choice and crop husbandry from charred plant remains, indicating shifting emphasis on crops and husbandry practice. Beyond the implications for the Roman agricultural economy, methodological considerations will be discussed. The poor preservation of charred cereal grains and frequent germination, especially at Roman sites, limits the application of isotopic techniques.
The phenomenon of drinking the milk of other animals is unique to humans and appears to have been adopted early in the emergence of mixed pastoral systems. The earliest farmers would likely, however, have been lactase non-persistent (LNP; also known as lactose intolerant), which has been widely asserted to be a barrier to regular milk drinking post-weaning due to generally perceived negative health consequences. In this presentation I will discuss the latest findings in which we map dairy product residues in >8,000 prehistoric food processing vessels from >150 European sites. Significantly, we show that dairying was a widespread phenomenon across all of prehistoric Europe, becoming especially dominant in the north in the 5th and 4th millennia BC. These findings will be discussed in relation to the frequencies of the most common lactase persistent (LP)-associated gene variant (-13.910*T), which appears to have been absent or present at very low frequencies amongst Neolithic farming communities, only increasing significantly in the Bronze Age. This challenges regularly made assertions that prehistoric LNP human populations would have been unable to incorporate milk into their diet. However, interrogation of the UK Biobank shows individuals lacking the LP genetic variant drink milk regularly without significant negative health effects. Hence, there is every reason to believe milk drinking would have been commonplace amongst prehistoric pastoralists, begging the question “How did lactase persistence (LP) evolve?”
The Proteomic Analysis of Ancient Dental Calculus from Eastern Africa: Current Applications, Pitfalls and Future Prospects

Madeleine Bleasdale, Jocelyne Desideri, Kate Faccia, Marie Bessie, Franziska Irmer, Paolo Nanni, Christian Trachsel, Shevan Wilkin, Muhammad Zahir, Monica Tromp, Abdourahmane Bourhane, Richard Helm, Mark Horton, Henry Wright, Alison Crowther, Jessica Hendy and Nicole Boivin

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Over the past two decades the development of high-sensitivity mass spectrometry has enabled palaeoproteomics to find a firm footing among the tools of archaeological science. A growing number of tissues and substrates have been investigated including the analysis of calcified dental plaque. Ancient dental calculus is a particularly rich source of information, encapsulating oral microbiota, activity, environmental and food-related debris and other dietary biomolecules during its formation. Here we present two contrasting case studies from eastern Africa where proteomics methods were applied. The first investigates the dietary practices of individuals buried at Kadruka, a Neolithic cemetery site in Sudan. Through the recovery and identification of species-specific milk proteins we were able to provide direct evidence for the consumption of goat’s milk. The second project explores the lifeways of the earliest settlers of the Comoros archipelago and their biological and cultural links to Asia and Africa. Dental calculus was analysed from a number of individuals from the 8th-10th century CE site of Membeni, Grande Comore. The majority of identified proteins were human oral bacteria, including a number of pathogenic bacteria associated with periodontal disease. Despite the samples exhibiting good overall preservation, no dietary proteins were identified. These contrasting studies raise important questions regarding protein recovery, identification and authentication. Palaeoproteomics is an emerging discipline but has already offered fascinating insights into ancient lifeways. We call for a more critical consideration of the application of proteomic methods to archaeological contexts in Africa.
DeamiDATE 1.0: Site-Specific Deamidation as a Tool to Assess Authenticity of Members of Ancient Proteomes

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Palaeoproteomics, the study of ancient proteins, offers new insights into the past, and is increasingly utilised where ancient DNA studies will fail, i.e. where the DNA in a given sample will have completely degraded, but the protein sequences remain somewhat intact. Additionally, proteins are tissue specific and can identify more than the organism, for example, tissue specific proteins in food such as seeds, meat or milk, or those expressed in particular disease states (Cappellini, Collins, and Gilbert 2014).

However, contamination is a potential issue in the study of ancient proteins, either from prior handling of the sample, laboratory consumables, or cross-sample carryover from mass spectrometers. Problematically, there are no commonly agreed upon measures to avoid protein contamination, or to authenticate the resulting spectra. Recently, deamidation has been proposed as a measure for assessing the degradation of ancient proteins. Here, we present deamiDATE 1.0 (currently in prep.), a method for the authentication of ancient proteins using measures of site-specific deamidation rates. We will demonstrate the results of this approach on shotgun proteomic data derived from modern collagen and bone as well as paleontological subfossils from extinct taxa. Lastly, we will showcase how this method may be used to differentiate between modern contaminants and authentic ancient proteins using a case study from Neolithic dental calculus.
Archival Proteins: Parchment Manufacturing and Its Effects on Collagen Degradation

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Using proteomics, we seek to assess the processing history of skins used for the manufacturing of parchment. Collagen, as one of the most abundant proteins in Cultural Heritage, is the focus of this study. Mass spectrometry was used to analyse the difference in the degradation levels of the collagen molecule derived from manufacturing processes in experimental parchment samples. The presence of other proteins in the parchment was analysed as it can help elucidate the treatments used for its production. With these analyses we aim to gain an understanding of collagen degradation pathways, and the chemical markers associated to skin processing, in order to develop improved and rapid methods to detect parchment production methods and history, and damage caused by skin processing and degradation.
The Shipwreck in a Diamond Mine

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Whilst mining for diamonds in 2008, mine workers in Oranjemund, Namibia found over 40 tons of cargo from a shipwreck buried under the sand for centuries. The ship is likely the Portuguese vessel Bom Jesus, which wrecked off the coast of Namibia in 1533 AD, and the artefacts found reveal aspects of European trade and contact with the western African coast in the early 16th century. The wreck was excavated as a rescue operation, and diamond mining continues along this stretch of the Namibian coastline. Among gold and silver coins, copper ingots, and navigational equipment, 100 complete tusks of elephant ivory were excavated and are currently being curated in the mine. In order to build a research and heritage project on the wreck, we started a program of biomolecular analyses on the 100 elephant tusks. We used a combination of ancient DNA and stable isotope analyses (δ13C and δ15N) to source the ivory to African habitats. We compare our shipwreck results to modern and historic isotope and DNA data from elephants across Africa. Our results show that the shipwreck ivory comes from different elephant herds of African forest elephants (Loxodonta cyclotis) which lived in mixed savanna habitats in inland western Africa. This study shows that a combination of techniques can be employed to determine the provenance of shipwreck cargo, to compare the genetic characteristics of ancient and modern wildlife populations, and to corroborate historical accounts of maritime trade routes. We hope that these data will aid in the exhibition of the artefacts in the National Museum, as well as publicize the outstanding heritage of this wreck to the wider public.
BIOMOLECULAR ARCHAEOLOGY

Why We Should ‘Play’ More with Stable Isotope Data – An Adventure in Multivariate Statistics and Anglo-Saxon Teeth

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Stable isotope analyses are frequently used to reconstruct diet and mobility in past populations, with usually only the absolute values being reported. However, there is a lot more to be extrapolated from these data, especially when considered together with other isotopic and cultural variables. This paper expands on Lightfoot and O’Connell’s (2016) statistical survey of stable oxygen isotope data by comparing, contrasting and combining descriptive, frequentist and Bayesian approaches. This allows for a more robust exploration of the data, especially for investigating variability at both a population and individual level. With the type of data we get from archaeological sources (which is often non-parametric), broader and more varied statistical methods are needed. A new dataset of 50+ individuals from Anglo-Saxon cemeteries in Kent, which display a bimodal distribution for oxygen values, are used as a case study, contextualised within other new and published carbonate data from across Anglo-Saxon England to demonstrate a multi-scalar approach. The outcomes of the variety of models and tests highlight the need to “play” with and explore stable isotope data in archaeology in a more robust fashion. These techniques are not isolated to enamel carbonate, but can and should be used for other isotope data (e.g. Sr/O, C/N, H/O) as well as other variables. These approaches to archaeological data, particularly in stable isotope studies, are under used, and allows for better characterisation of the data and greater interpretative power archaeologically. So I ask: Why do we not “play” with our data more?
BIOMOLECULAR ARCHAEOLOGY

Simultaneous $\delta^{13}$C, $\delta^{15}$N and $\delta^{34}$S Analysis of 1mg of Bone Collagen: Analytical Improvements

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The measurement and understanding of sulphur isotopes in bone collagen is a rapidly growing field. Sulphur isotopes in proteins preserved in archaeological material can potentially distinguish between marine and terrestrial diets, being especially useful when the dietary interpretation of $\delta^{15}$N is complicated by aridity or nutritional stress. There is also potential to use sulphur isotope values as a provenancing tool because of their relationship to underlying geology. However, $\delta^{34}$S studies are still not applied routinely in the same way as $\delta^{13}$C and $\delta^{15}$N analysis. This has in some way been hampered by the large amount of organic material required per measurement; at least 10 mg for an individual analysis. This is due to the low concentration of sulphur in bone collagen (0.2% to 0.3%). In contrast, a dual carbon and nitrogen analyses can be achieved with less than 1 mg of material. Additionally, it is usually necessary to analyse $\delta^{34}$S separately from $\delta^{13}$C and $\delta^{15}$N, often with equipment adaptations. Thus, this has made the analysis of $\delta^{34}$S expensive, both in terms of time, sample destruction and cost. This presentation describes how a simultaneous triple $\delta^{13}$C, $\delta^{15}$N and $\delta^{34}$S analysis is achievable in a single sample drop on a collagen sample of 1 mg using the Thermo Scientific™ EA IsoLink™ IRMS System. This means that the overall cost per sample analysis is reduced, less maintenance is required and system throughput is significantly enhanced. This is without compromising on analytical precision, which we show to be $\leq 0.1\%$ for $\delta^{13}$C, $\leq 0.15\%$ for $\delta^{15}$N and $\leq 0.3\%$ for $\delta^{34}$S. This method provides new opportunities for data collection and, in the case of sulphur, the routine analysis of $\delta^{34}$S in bone collagen.
The introduction of domesticated animal milk into the human diet marked a pivotal step in the opening of marginal environments for nomadic pastoralism through newly available secondary products. While dairying is extremely common in modern day Mongolia, the antiquity of this practice in the region is largely unknown. This talk will detail progress made on a large-scale ongoing collaborative project, which includes the proteomic and microscopic study of ancient dental calculus, paleopathological skeletal assessments, as well as genetic, genomic and isotopic analyses to determine when milk entered the eastern steppes, and what effects its incorporation had on ancient Mongolian populations. From the over 200 individuals sampled, we found that dairy was introduced onto the Eastern Steppe by 3000 BC, 1500 years earlier than recently reported. Furthermore, we found that the consumption of horse milk, a common social practice across the steppe was common by the Late Bronze Age (ca. 1200 BC). Through stable isotope analysis, we also found that C4 consumption, likely millet, was common during the later Xiongnu (ca. 200BC – 100 AD) and Mongol Empires (ca. 1200 – 1400 AD) and dietary diversity was much larger than in the previous Bronze Age. (Genetic and genomic analyses will be presented if the data area ready).
Keeping Tabs on Cattle Mobility through Geometric Morphometrics, Finite-Element Analysis and Cross-Sectional Properties

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Understanding how animals moved during their live is a key step to broaden our knowledge on human-animal interactions and, as an ultimate goal, how different management strategies might give shape to human societies while animals adapt to further human necessities. Under the premise that bone is a plastic tissue with the ability to adapt to mechanical stresses, evaluating differential bone growth should give relevant information about how animals moved, how they were made to move or restraint, during their live. Computerized tomography is a diagnostic imaging technique that can provide information about the internal and external structure of bone tissue. 3D models of cattle phalanges from different Mediterranean Neolithic sites were digitally reconstructed to evaluate different aspects of its morphology, provided that different mobility patterns might have relatable effects on bone development. The morphology of the proximal end of the phalanges was evaluated using geometric morphometrics, mapping the surface with landmark and sliding surface semi-landmarks. Bone loading, bending and torsional strengths were documented and analysed through geometric morphometrics on middle-shaft cross-sections of the phalanges. Moreover, overall bone resistance to loading forces was calculated using finite element analysis. Cattle has a relevant role in many Neolithic sites, since more than an important source of meat it can also provide milk and labour force while it’s still alive. The results obtained open a new path into understanding cattle mobility and specific management strategies that might be dependent on different exploitation purposes.
Travelling Amphorae and Thirsty Seafarers at the Temple of Kommos

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The Iron Age ceramics found at Kommos, a coastal site in southern Crete (Greece), are of different origin. According to petrographical analysis and shape studies, most of the sherds are of local manufacture. Nonetheless, a number of pots and fragments come from the north of the Aegean Sea and others belong to the Lebanese coast, specifically from the Phoenician homeland. The thicknesses of the Phoenician sherds, their shapes and glazes have been studied in detail. Even though none of these ceramics were complete, they have been drawn and measured in order to provide an approximation of what they would have looked like. The ceramics studied belonged, based on their style, to the Proto-Geometric and Geometric periods, dating from the 8th to the 6th centuries BC. These present a great amount of thick pots with closed shapes, identified as transport jars that would presumably have contained oil or wine, as well as thin and decorated vases of open shapes understood as drinking and serving vessels. The context where these pots were found also needs to be taken into account. They were discovered inside of a Greek temple dedicated to Cretan trinity of Apollo, Artemis and Leto. However, some figurines of Egyptian gods and other Near Eastern objects suggest that the temple was not only used by these Cretan worshippers, but maybe also by the foreign seafarers who would stop at the temple in order to exchange goods, as the amphorae might attest, and to have a drink with the locals before continuing their journey.
While there has been much speculation as to how and why Stonehenge was built, the question of ‘who’ has received far less attention. Part of the reason for this neglect is that most of the human remains were cremated, and so it was difficult to extract much useful information from them. Recent work, however, showed that information about mobility and funerary practices could be obtained from cremated human bone by combining C, O, Sr isotope analyses and infrared analyses. The Sr results show that 10 out of 25 cremated individuals buried at Stonehenge did not live near Stonehenge prior to their death. Instead, some of these might actually have come from other parts of the UK, including west Wales, from where the bluestones used to construct the first phase of the monument originate. The C, O and infrared results further suggest that those buried at Stonehenge were not burned at the site but brought to the site after cremation.
Molecular Analysis of Ritual Black Liquids Applied to Ancient Egyptian Coffins

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Several 22nd Dynasty Egyptian coffins in the collections of the British Museum have been painted with a black coating over which yellow hieroglyphs have been drawn, and there are examples of the application of a black liquid over cartonnage and coffins, presumably during funerary rituals. In some cases, this has been poured over the entire body and in others it is confined to a smaller area, such as the face. What are these black substances, where were they sourced from, and why were they applied? The ingredients of the liquid will have determined its material properties and contributed to its ritual significance.

To determine the components of the various black substances, samples have been analysed using GCMS. Both the undercoat and the ritual liquid are a complex mixture of organic components including plant oil, resin, beeswax, and bitumen. Bitumen was found in every sample. Biomarkers from the original plants and algae that formed the bitumen can be used to identify the geological source of the bitumen and therefore the geographical range over which trade for this product took place.
Application of Image Analysis for the Identification of the Ceramic Pottery Production Technologies of the North Caucasus (Russia) in the Bronze/Iron Age

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In this study, 2D-/3D-image analysis was mainly performed using Matlab for the main topics in the ceramic pottery production: resource gathering, firing degree and shaping techniques. Images were acquired by polarized light microscopy, BSE and 3D μ-CT. For this purpose, 70 ceramic sherds excavated at Ransyrt 1, an archaeological site occupied in the Middle-Late Bronze Age in the North Caucasian mountains, Russia and at Kabardinka 2, located in the lower plateau in the same mountains (Late Bronze/ Early Iron Age) were analyzed. For the identification of the resource gathering strategy, shape parameters of sand grains within the ceramics and for the estimation of firing state, pore topology and shape parameters of ceramic matrix dominated by the clay sintering were measured. The 2D and 3D image processing data were compared to each other. Shaping techniques of the ceramic body were analyzed using various alignments of segmented large pores and sand grains in 3D. Based on the results, size distribution, circularity and sphericity of coarse sand grains (>250µm) show site specific differences in the preparation of ceramic pastes. At the same time, each site has several groups according to each parameter, indicating different recipes. Sphericity, surface area, volume and Euler characteristic of open and closed pores were useful to estimate various firing states between the samples and within the sample qualitatively/semi-quantitatively. This was supported by the laboratory based FTIR/SR-FTIR. These samples would be formed in similar ways except of some details. Despite of the heterogeneity of archeological ceramics, this approach could provide the categorization of the samples for each topic in the ceramic pottery production, so that its local technological styles can be reconstructed.
Debunking the Dentine: Micro-CT and Histological Assessment of a Mineralisation Defect in Teeth Attributed to Vitamin D deficiency in two 17th – 19th Century Dutch Communities

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Recent research yielded relatively high prevalences of rickets (15 – 24%) and residual rickets (15 – 24%) in two 17th - 19th century Dutch communities, Beemster and Hattem. However, macroscopic examination provides limited information on vitamin D deficiency development. Microscopic computed tomography (micro-CT) analysis of interglobular dentine (IGD), a dental mineralisation defect attributed to vitamin D deficiency, provides information on the age of onset and the number of deficient episodes per individual. Thirty teeth were micro-CT scanned. One tooth was deemed unobservable and 65.5% (19/29) of the remaining individuals display IGD. Thin sections were made of 17 teeth, including six teeth for method comparison and the 11 teeth without observable IGD. Eight of these 11 individuals (72.7%) demonstrated histologically visible IGD. The majority of affected individuals (63.2%; 12/19) display the first observable band of IGD between 6 and 12 months of age, and most individuals (89.5%; 17/19) do not display bands of IGD after the age of about 3 years, suggesting an improvement in sunlight exposure after this age. Furthermore, in 40.7% (11/27), this disease was recurrent, visible as two or more bands of IGD. Comparison of the results of macroscopic, micro-CT, and histological analysis suggests the latter to provide the most accurate prevalence of vitamin D deficiency. However, micro-CT analysis of IGD is found to be a valuable non-destructive method that aids in the identification of affected individuals and increases our knowledge of vitamin D deficiency patterns within past communities.
Application of Advanced Tomographic Imaging in Understanding the Origin and Evolution of Human Cancer: Issues of Quantitative Histopathology, Homology, and Clinical Validation


The published incidence of neoplasia in the human lineage has been rare, with only a few confirmed cases of Middle or Later Pleistocene dates reported. It was generally assumed that pre-modern incidence of neoplastic disease of any kind was rare and limited to benign conditions, but new fossil evidence suggests otherwise. Recent work by the authors has provided evidence for the antiquity of human cancers and tumours, with the earliest identifiable cases of malignant and benign neoplasias from early hominins dated to 1.8–1.7 million years old from the South African cave sites of Swartkrans and Malapa, and more recent material from the Middle Pleistocene site of Rising Star. Confirmed diagnoses have only been made possible by advances in 3D imaging methods as clinical diagnostic aids, in particular the use of high-resolution phase-contrast synchrotron and micro-computed tomography. The expression of osteosarcoma in the Swartkrans specimen indicates that there is no reason to suspect that primary bone tumours would have been any less frequent in ancient specimens. Such tumours are not related to lifestyle and often occur in younger individuals. As such, neoplasia (malignant or benign) has a considerable antiquity in the fossil record. This paper addresses the diagnostic methodologies employed, particularly the evaluation of palaeopathological and osteological criteria from tomographic volumes, and how this can be used to define pattern and process in pathological bone. Issues of quantifying and qualifying cellular homology in histopathological image volumes will be discussed. In particular, approaches which move beyond standard qualitative clinical or palaeopathological diagnostic methods, to ones based on robust segmentation and quantification of traits such as trabecular morphology, neurovascular structure, and cortical ultrastructure of fossil and recent bone will be discussed.

Looted Ancient Egyptian Tomb – Mummy Restoration in Ancient Times
The Dakhleh oasis was a trading centre in ancient Egypt. Some mummies from the Dakhleh Oasis show evidence of ancient restoration by priest after the tomb was looted. To investigate this a mummy was chosen that had a thin layer of resin on the outside but had otherwise undergone spontaneous mummification. This mummy also had embalming materials in unusual places, suggesting at some point in ancient times, after the initial mumification, it had been restored. To investigate if different materials were used, skin tissue was analysed using gas chromatograph mass spectroscopy (GC-MS) and this was compared with a sample from the liver. Since this mummy had not had organs removed, any material on the liver should been from a later restoration. It was found that the embalming material was different. Bitumen from Hit, a well-known highly regarded source was found on the skin, but bitumen of another unknown source was found on the liver. Bitumen from the liver resembles oils in the Gulf of Suez or Iran but has not yet been linked to a known ancient seep. It appears the priest who restored the mummy may have used a cheap source of bitumen or whatever was available. Pine resin (Dehydroabietic acid) was found along with retene, suggesting it was heated. Rapeseed oil appears to have been used possibly along with beeswax. It is also interesting that hydrocinnamic acid has been discovered on the liver but not on the skin. Rosemary is a possible source for this and as rosemary was also found in the tomb, it is possible that it was used in the embalming mixtures. Further investigation is needed to determine if beeswax was used. Ideally elemental analysis and isotope analysis would also be used to confirm Hit as the source and determine the other source of bitumen.
Scientific Analysis of Metal Objects and Glass Unearthed from the Han Zunian Tomb of the Northern Qi Dynasty (550 AD – 577 AD), China

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Metal objects and glass dating back to the Northern Qi Dynasty (550AD-577AD) were unearthed from the Han Zunian Tomb in Taiyuan, Shanxi Province in 1982. Author used microscopy and X-ray fluorescence, two nondestructive methods, to study these relics. The results show that (1) the gilt bronzes were formed by casting and then were surface-treated using heated gold amalgam and (2) the technology and the style of the gold, silver wares and glass were influenced by the cultures of Western and Central Asia. This research provides important scientific information for the comprehensive understanding and further study of metal-ware and glass technologies of the Northern Qi Dynasty.
Faecal Biomarker Analysis of Coprolites as a means of Investigating the Nature and Timing of the Earliest Human Occupation of North America

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The question of how, when and why people first settled the Americas has been a subject of intense debate which continues to the present. There are two schools of thought, the ‘Clovis First’ and ‘Pre-Clovis’ theories, with the former asserting that the Clovis culture was the earliest human presence in North America arriving ca. 13,500 cal BP. Evidence of ‘Pre-Clovis’ human occupation in North America obtained through DNA analysis of coprolites from the Paisley Caves, south-central Oregon, has dated the earliest occupation to 14,300 B.P., one thousand years earlier than previous evidence suggests. Coprolites (semi-fossilised faeces) contain a suite of lipid biomolecules and are an invaluable source of palaeobiological and palaeoecological information. The identification of faecal matter through the presence of highly-specific lipid biomarkers (5β-stanols and bile acids) has been used to identify and characterise faecal input from a range of different sources. Differentiation of these faecal markers is enabled through the diet, digestion and metabolism of the source animal. Lipid analysis of coprolites has also been used to identify dietary biomarkers, providing information regarding available plant resources. Here, a lipid biomarker approach has been applied to coprolite and associated sediment samples from the Paisley Caves with the aim of identifying the timing of the earliest occupation of North America by firstly characterising the origin of coprolites found in well-stratified archaeological deposits and then by using compound-specific ¹⁴C dating of 5β-stanols to precisely date the human presence in the cave. Biomarker analysis has also been applied to investigate the nature of the earliest occupation human of North America through dietary reconstruction which will enhance our understanding of the relationship between early humans and their environment.
Exploring Sources of Lead in Children during Colonial Settlement of Northeastern North America during the 18th and 19th Centuries

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Tooth enamel is an important isotopic data source and has been increasingly used in studies of lead exposure in archaeological populations. Since teeth form during childhood and lead exposure reflects individuals’ interactions with their physical and cultural environments, this tissue presents an ideal means of examining migration and lead sourcing in archaeological groups. Lead toxicity is generally associated with ambient air pollution, occasional acute exposure from mining/industrial activities or accidental ingestion. Because there was no mining of lead-bearing resources in Atlantic Canada during the 18th and 19th centuries, any lead exposure in these colonial populations would reflect European sources of lead likely ingested from contaminated cultural materials (e.g., utensils, storage and serving vessels). Therefore, the objective of this study is to associate isotopic lead concentrations to specific cultural materials that can be tied to distinct European regions to help decipher the origins of early colonial populations in Newfoundland and Nova Scotia. Tooth enamel was collected from 38 individuals representing four Newfoundland settlements and the original colony from the Fortress of Louisbourg in Nova Scotia. Samples were preferentially taken from the second molars as they represent the longest period of childhood between 2 and 8 years of age. Lead concentrations and isotope ratios were determined using Solution-ICPMS and MC-ICP-MS, respectively. These data suggest that there is a common source of lead in both these 18th-19th century Newfoundland and Nova Scotia colonial populations. More specifically, these values are consistent with English lead ore. These results suggest that despite the heterogeneity of these early Atlantic colonies, there was a common lead source, likely associated with shared and traded cultural materials. Through the use of lead concentration and isotope analyses, our study provides preliminary insight into our understanding of these various colonial populations and their cultural materials in the 18th and 19th Atlantic world.

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Iron Age mortuary rites in Britain have long been debated. Human remains commonly occur in unusual configurations including articulated limbs, isolated skulls, poorly preserved fragments and (rarely) complete skeletons. These are found in small quantities, often in storage pits and ditches. Explanations for the deposits have been wide-ranging including cannibalism, warfare, curation, haphazard disposal and human sacrifice. Excarcarnation, which here refers to defleshing through sub-aerial exposure, has tended to be the dominant interpretation. However, little scientific analysis has been undertaken to characterise practices and to assess why minority rites were enacted for only certain people.

This study combines thin section microscopy, multi-isotope analysis (δ¹⁸O, δ¹⁵N, δ¹³C, ⁸⁷Sr/⁸⁶Sr) and trauma research on 124 deposits of human remains from five high profile hillforts and settlements in Iron Age Somerset. Taphonomic alterations to bone microstructure generally reflect early post-mortem treatment and microscopic analysis can therefore indicate processes of bodily disarticulation, key evidence for reconstructing mortuary practices. These data were combined with isotope and trauma research to assess whether there were patterns of treatment relating to origins, diet or violent death. Microscopic analysis indicated that the vast majority of individuals were not excarnated, but rather became disarticulated after initial burial. Therefore, exhumation combined with selective retrieval, circulation and redeposition seems to have been the most common practice. One site (Glastonbury Lake Village) showed a different pattern, with the majority of individuals apparently having been excarnated, although this may relate to the taphonomic context of the site’s environs. Numerous non-local individuals were identified, several of whom are likely to derive from the continent. However, no clear patterns were observed between mortuary practice and origins, diet or trauma evidence. This might indicate the transformation of remains from individual to malleable resource after death, regardless of whether friend or foe, native or non-local.
Survival Comparative of a Medieval Hospital and Lay Cemeteries

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This study looked at the survival demographics between individuals associated with hospitals and cemeteries during the medieval period in Chichester, Gloucester, and Pontefract, England. Lay and hospital communities had similar and different influences on the outcome of people’s health. Indicators of stress, linear enamel hypoplasia and cribra orbitalia, were analysed to determine the levels of health between individuals associated with St. James and St. Mary Magdalene Hospital (n=90) and Box Lane and Blackfriars lay cemeteries (n=90). The results suggested there was not a significant difference between individuals associated with both the hospital and lay cemeteries age-at-death (p=.67) and stress indicators (adults p=.56, non-adults p=.26). Although, the survival curves suggested individuals associated with the hospital had a higher chance of survival before the age of 30 than individuals from the lay cemeteries.
Over the past two centuries, archaeological finds have been, often inadvertently, recovered from various locations along the course of the River Thames. Amongst these finds are ornate metalwork, organics, and human remains (most commonly, crania). Artefacts and ecofacts found along the Thames have been dated from prehistoric contexts all the up to the present day. The oldest discovery thus far are the remnant timbers from a Mesolithic structure recovered from Vauxhall (Milne et al. 2010). The vast span of dates reinforces the importance of the River Thames as a centre of human activity for of thousands of years. Hundreds of human crania have been recovered from riverbank contexts, but seldom have been subject to further study. To date, 24 skulls have been radiocarbon dated, ranging from Neolithic to the Medieval periods. Although 83% of the 24 skulls produced Pre-Roman radiocarbon dates, it is not clear whether this result represents the collection or a sampling bias. Here, we present the results of ancient genome analysis conducted to further understand the London demographic through the ages. DNA was extracted from the petrous bone of 30 Thames skulls and subjected to whole genome re-sequencing. The obtained ancient sequences were compared to previously published genomic data derived from modern and prehistoric European populations. We discuss the ancestry and demography of the Thames skulls in the context of previously identified genetic influence coming from Anatolian farmers and various Northern European populations.
Osteobiography of a Potter near the Oupan Kiln, Anhui, China during the Early Tang Dynasty (544 – 644 cal. AD) by Osteological and Multistable Isotopes Approach

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More and more attention has been paid to the reconstruction of life histories from the scale of population shifting to that of individuals, through the stable isotope analysis of different skeletal elements or sequential sampling of teeth dentine. However, none of research has focused on the ordinary individual with low social status. In this study, a clear pattern of osteobiography of a potter dated to the Tang Dynasty (544-644 cal AD) was revealed, by the methods of osteological observations and multiple stable isotope analysis of his bones and teeth. Some important information on his weaning practice, unstable life and pathology was discussed, which was highly related to his social status as a potter. Our study encourages the needs to understand the subsistence, health and life history of the individuals with low social status in the near future.
The Genomics of Megaliths: Exploring Social Structure in Irish Neolithic Civilization through Ancient DNA Analysis

Lara Cassidy and Dan Bradley

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The Irish Neolithic marks the emergence of complex societies on the island, alongside the establishment of continued contacts with other Atlantic regions, which intensify in the succeeding Copper and Bronze Ages. In addition to these cultural upheavals, the Neolithic is now known to have both begun and ended with mass migration to the island, potentially from multiple external sources. Throughout these periods Atlantic communities engaged in monument building on a mass scale, most evident in their construction of megalithic burial tombs, which reach their highest diversity and concentration in Ireland today. We present the genome sequences of over 40 Irish individuals from such contexts and use this data to examine the structure of the societies who built these tombs, as well as the identities of the individuals interred within. Dense sampling across time intervals of known demographic flux allows us to examine the complex interplay between geography and culture in the assimilation of new peoples to the island, while genomic sequencing to a median of 1X, allowing for the imputation of diploid genotypes, provides a mean to dissect subtle patterns of relatedness among more homogenous Irish populations during periods of genetic continuity. With these methods we find cultural drivers of genetic structure in our dataset, related to burial type, as well as the persistence of older ancestries in the geographical extremes.
POSTER PRESENTATION ABSTRACTS:

24th – 26th April: Manchester Institute of Biotechnology
1.
Comparing Stable Carbon Isotopes of Tooth Dentine and Enamel: Evidence for Dietary Routine in Cattle?

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In recent years many studies have reported serial isotopic measurements of tooth enamel and/or dentine to reconstruct dietary and environmental changes over the period of tooth formation. This paper compares the $\delta^{13}C$ values from serial sampling of both enamel and dentine from 22 cattle teeth from the Iron Age site of Great Zimbabwe. For both tissues, samples were taken as horizontal transverse slices. This methodology is known to introduce time-averaging, but nevertheless allows for detection of seasonal dietary variation. In Zimbabwe, cattle consume mainly $C_4$ graze, in some cases supplemented by $C_3$ browse during the dry season. The difference between the mean enamel and mean dentine values per tooth is 8.77 ± 0.64‰. These two values are highly correlated ($r^2 = 0.77$). Mean $\Delta^{13}C_{\text{enamel-dentine}}$ is more strongly correlated with $\delta^{13}C_{\text{enamel}}$ ($r^2 = 0.40$) than with $\delta^{13}C_{\text{dentine}}$ ($r^2 = 0.03$). In individuals that consumed some browse, variation in $\delta^{13}C$ profiles can be significantly different in enamel and dentine. It is unclear to what extent this difference results from dietary routine and/or metabolic processes involved in enamel and dentine formation, compared with time-averaging resulting from the sampling methodology employed. The implication is that isotopic profiles based on serial sampling are directly comparable only if derived from the same tissue. Previous studies of $\Delta^{13}C_{\text{collagen-carbonate}}$ have focused on trophic level and digestive physiology. We show here that this can vary substantially even within a single herbivore species.
2.

Anadromy and the Archaeological Record: Exploring Stable Carbon Isotope Records for Ancient Aquatic Resource Use

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Migratory fish such as salmon have long been a highly valued resource for coastal peoples around the world, but determining the relative importance of different salmonids can be challenging due to the morphological similarity of the bones from many taxa. Some of the most culturally important salmon species exhibit variable life histories, with some populations being freshwater residents (sometimes called “landlocked”) and others anadromous (migrating to the ocean and back). While aDNA and ZooMS offer an effective means of determining which species are present, current techniques cannot establish which behavioral type was important (i.e., freshwater vs. anadromous). Knowing the relative importance of these behavioral variants in the archaeological past can help establish a framework for interpreting seasonality and fishing strategies. In this study we develop and demonstrate a method for distinguishing between sockeye (anadromous) and kokanee (freshwater) – two behavioral variants of the same species (Oncorhynchus nerka) – using stable carbon isotope analyses of collagen from bones and scales of archaeological, modern, and museum-archived fish. Results from more than 300 sockeye and kokanee from over 40 sites distributed around the northern Pacific Rim (from Russia to Washington State, USA) show a clear isotopic distinction between sockeye and kokanee regardless of where they were collected. This method should also provide an effective means of differentiating other salmonids with variable life histories, such as steelhead and rainbow trout (both Oncorhynchus mykiss). We advocate that a combined use of isotopic analyses and ZooMS/aDNA could provide an unprecedented level of detail on the history of salmon fisheries.
3.

Humans and Their Environment in the Past: Using Stable Isotopes to Investigate the Collapse of the Kushite Kingdom of Meroe (300 BC – AD 350), Sudan

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The circumstances surrounding the collapse of the Kushite Kingdom of Meroe (c. 300 BC – AD 350) in the present-day Republic of Sudan remain unclear and open to speculation. The available historical and archaeological evidence points to several likely causes for the decline and eventual fall of the kingdom in the 4th century AD; the most frequently cited factors being political and economic instability, and social unrest. Recently, the environmental changes resulting from overexploitation of the natural environment due to a large-scale iron production and agricultural intensification have been put forward as a contributing factor to the fall of Meroe. The environmental changes hypothesis and their potential impact on human habitation, migration and subsistence during the Meroitic (300 BC – AD 350) and Post-Meroitic Period (4th – 6th Centuries AD) were investigated using carbon, oxygen and strontium stable isotopes analysis. Dental enamel samples from human remains recovered from a total of 13 archaeological sites, mostly from the heartland of the Kingdom of Meroe, were subject to δ^{13}C, δ^{18}O and δ^{87}Sr/δ^{86}Sr analysis, along with animal remains from burial deposits – when available – and samples of local vegetation. Isotopic values were chronologically grouped based on the radiocarbon dates obtained from human remains to detect environmental and dietary changes and periods of intensified migration. It is hoped that the results of this research will aid our understanding of the circumstances surrounding the collapse of the Kingdom of Meroe and the human-environment relationship in the past.
4.

PleistoHERD: Linking Intra-Tooth Isotope Profiles and Isoscapes to Reconstruct Prey-Species Palaeomigrations using Computational Modelling

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Reconstructing the palaeoecology of prey-species is crucial to the study of ancient living landscapes and to better understanding the decisions, movements and hunting strategies of past human groups. Traditionally inferred from the ecology of modern analogue species, our ability to reconstruct past behaviours has greatly improved with the development of isotope techniques that target incrementally developed tissues. Strontium ($^{87}\text{Sr}/^{86}\text{Sr}$) and oxygen ($\delta^{18}\text{O}$) isotope analysis of sequentially-sampled tooth enamel can be used to evidence migratory behaviour, and provide an indication of possible seasonal ranges. However, more nuanced approaches, linking intra-tooth isotopic profiles and isoscapes, are required to reconstruct past migratory routes across landscapes. This project aims to develop an isoscape-based model, the PleistoHERD model, to assess the distribution and migratory movements of animals from their intra-tooth $^{87}\text{Sr}/^{86}\text{Sr}$ and $\delta^{18}\text{O}$ isotope data. Here we present the methodological framework of this model, integrating intra-tooth and landscape isotope data using GIS analysis and movement modelling methods from modern ecology. In developing the model, we use intra-tooth isotope profiles from modern migratory caribou from the Rivière-aux-Feuilles herd, Québec, Canada, alongside creating a working $^{87}\text{Sr}/^{86}\text{Sr}$ isoscape, based on the age and nature of the lithology of Québec, supplemented by bioavailability strontium isotope data from modern plants, and refined using Random Forest modelling. A Bayesian spatial assignment approach is used to identify the origin of every intra-tooth sample from each individual, and produce a time-series probability distribution map for each caribou. Caribou movements are modelled throughout the time-series distribution map to identify potential seasonal ranges and migration routes. The comparison of reconstructed seasonal movements with real migrations, assessed from the telemetric survey of the Rivière-aux-Feuilles herd, will allow us to validate the model. The implications of the PleistoHERD model, and its interdisciplinary approach, for the use of strontium isotope analysis in archaeology and palaeoecology will be explored.
3D Imaging for Visualising Roman Activity at Vindolanda

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Museums have an ethical code to educate and undertake research. 3D imaging removes access issues to archaeological material by providing accurate replicas of artefacts. These models provide a direct encounter with heritage while protecting the archaeological record. This project discusses the excellent potential in 3D imaging for enhancing these objectives at Vindolanda Museum, Northumberland UK.

Vindolanda is a World Heritage site at the Frontiers of the Roman Empire, located along Hadrian’s Wall. The conditions at Vindolanda result in the recovery of delicate, exceptional artefacts. A collection of skulls, including ox skulls used for target practice, were scanned using a 3D structured light scanner and processed into print-ready 3D models.

The features presented in the skulls provide evidence of highly-skilled Roman archers participating in archery target practice. The 3D digital and printed models provided potential for the public to directly interact with the excavation site and the complex, contextual information it presented, whether in the museum or online. These interactions provided deep and effective learning.
6.

Diet in English Medieval Hospitals: A Stable Isotope Study

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The medieval hospital of St John the Evangelist, Cambridge (c.1195-1511) was a charitable institution primarily providing respite and spiritual care for the deserving poor (Rubin 1987). Nourishing food was an important aspect of this care; the rules of the hospital refer to provision of meat dishes to fortify the sick, although remaining hospital accounts indicate it is likely that meat was only eaten c.3 days a week, in line with religious dietary instructions (Rubin 1987). Whilst we have some indication of diet from historical accounts, it is unclear how much variation in diet there was within hospital populations. Carbon and nitrogen stable isotope analysis of archaeological skeletons has the potential to allow us to investigate diet within medieval hospitals, but has thus far been little utilised in England, with the notable exception of the hospital of St Giles, Brough (Müldner et al. 2005, Bownes et al. 2018). This poster presents the results from new isotopic analysis of the population from the hospital of St John the Evangelist. These data demonstrate a large range in δ¹³C and δ¹⁵N values, much greater than other populations analysed from medieval Cambridge. This could imply a diversity in diet within the hospital and/or a diversity in the diets of the people before they were admitted to the hospital, due to the turnover of the tissues analysed. Comparison with St Giles, Brough, shows differences in the stable isotope data, suggesting that hospital diets varied by institution and that studying hospital populations may provide an interesting cross-section of Medieval town society.
Experimental Approach to detect the Presence of Garments Worn by the Deceased through Stable Isotope Analysis ($\delta^{13}$C, $\delta^{18}$O)

Kevin Salesse $^1$, Christophe Snoeck, Rica Annaert, Mathieu Boudin, Giacomo Capuzzo, Sarah Dalle, Guy de Muller, Marta Hlad, Ioannis Kontopoulos, Charlotte Sabaux, Amanda Sengeløv, Elisavet Stamatakis, Dries Tys, Barbara Veselka, Eugène Warmenbol and Martine Vercauteren

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If post-cremation life histories of cremains and cremation-related deposits can be readily investigated as they refer to the last handling of the deceased, the treatment of the corpse during the burning act itself is little addressed by textual sources and often discussed in anthropological studies. Among the topics discussed are questions whether the individuals were buried clothed or not and criteria for evaluating indirectly the wealth of deceased or their social statue in the past. Here we aim to identify, through stable isotope evidences ($\delta^{13}$C, $\delta^{18}$O) on calcined bones, if the deceased was buried shoed or not, as the shoes are likely one of the most resistant clothing items to fire and might represent a proxy to discuss the presence of any garments items inside the burial. For this, we have carried out experimental cremations with shoed and un-shoed pig feet (n=12) in outdoors pyres in Belgium. It is hypothesized that foot bones encased in shoes might experience heating conditions characteristic to confined-space cremation (low oxygen availability, poorly ventilated). These heating conditions could be related to the fact of presence or absence of shoes. Recent advances in biogeochemical techniques present a unique opportunity to finally be able to characterize the cremation and bring a new breakthrough in our current archaeo-anthropological knowledge of the burning act itself through time.
Mobility at Heath Wood Viking Cremation Cemetery, Ingleby, Derbyshire: The Isotopic Evidence

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The changes observable in the funerary archaeology of the early medieval period in Britain - especially in the context of the re-occurrence of the cremation rite - have often been linked to the movement of people. This is the case first during the fifth and sixth centuries when cremation burials appear with the arrival of the Anglo-Saxons and later in the ninth and tenth centuries, when the first Scandinavians reached the shores of Britain. Most funerary evidence for a Viking presence in Britain occurs in the form of inhumation burials and only one cremation cemetery from this period has so far been discovered: the barrow cemetery at Heath Wood, Ingleby, in Derbyshire. This cemetery consists of fifty-nine known burial mounds of which a small number have so far been excavated to reveal cremation deposits (Richards 2004). It is believed that the cemetery is linked to the historically documented over-wintering of the Great Viking Army at Repton in AD 873-4 and thus, by its very nature, has high potential to include foreigners to Britain. We used a relatively new method for strontium isotope analysis suitable for cremated bone (Snoeck et al 2015) in order to explore the origin of a small selection of animals and humans recovered from two mounds. With this poster we present, for the first time, indications for mobility based on strontium isotopes in cremated individuals and animals from the early medieval period in Britain. This highlights the potential of the method for other early medieval sites which contain a large number of cremation burials, but which have so far remained unexplored isotopically.
At the Fringe of Indus Civilisation: What Can We Tell About Indus People at Khanak, Lohari Ragho I and Masudpur I through Macro-Botanical Remains

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Khanak, Lohari Ragho I and Masudpur I archaeological sites lies at the fringe of the Indus Civilisation in northwest India and provide unique insights into agricultural production in contrast to the typical focus on large scale sites within Haryana region. The Indus Civilisation developed in a climatically challenging region, characterised by environmental and climatic diversity. This presentation aims to explore what can macro-botanical remains tell us about apart from agricultural production of Indus civilisation. This paper presents the results identification of different cropping choices and also investigates different types of choices made by Indus population, including differential site use (craft production areas vs. household areas), choices of fuel (manure vs. wood), management of the landscape, the impact of seasonality, and consideration of how climate change impacted these choices over time.
10.

Survival Comparative of a Medieval Hospital and Lay Cemeteries

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This study looked at the survival demographics between individuals associated with hospitals and cemeteries during the medieval period in Chichester, Gloucester, and Pontefract, England. Lay and hospital communities had similar and different influences on the outcome of people’s health. Indicators of stress, linear enamel hypoplasia and cribra orbitalia, were analysed to determine the levels of health between individuals associated with St. James and St. Mary Magdalene Hospital (n=90) and Box Lane and Blackfriars lay cemeteries (n=90). The results suggested there was not a significant difference between individuals associated with both the hospital and lay cemeteries age-at-death (p=.67) and stress indicators (adults p=.56, non-adults p=.26). Although, the survival curves suggested individuals associated with the hospital had a higher chance of survival before the age of 30 than individuals from the lay cemeteries.
11.

Zooarchaeological Analysis of the Micromammal Remains from the Middle and Upper Palaeolithic Deposits of Shanidar Cave (Iraqi Kurdistan)

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Climatic fluctuations are frequently suggested as having influenced the replacement of Neanderthals by Anatomically Modern Humans (AMH), which occurred roughly between 45-30,000 years ago. It is hypothesised that climate induced changes in ecological productivity may have favoured this transition. Shanidar cave offers a perspective on this transition as it is located on a major route of hominin dispersal out of Africa and archaeological deposits indicate that both Neanderthals and AMH have been present in the cave at different points during its sequence. Zooarchaeological analyses focusing on the micromammal remains can provide a high resolution and localised record of any environmental changes associated with this transition. In this poster I present the preliminary micromammal zooarchaeological results for all excavation seasons prior to 2018 with samples taken throughout the Middle and Upper Palaeolithic layers of the excavation. In each sample the teeth were sorted from the postcranial material and identified. As material was taken from several sample columns the micromammal community could be tracked and compared throughout the sequence. Analysis of the combination of taxa present at different points in the sequence and fluctuations in their abundance has been used to infer the local environment of the cave. Future results produced from these analyses will allow a detailed reconstruction of the local palaeoecology of the cave and a greater understanding of the environmental context of the Neanderthal-AMH transition in Southwest Asia.
12.

Ancient Genomic Analysis of Multi-Faith Populations from Medieval Sicily

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Introduction: The SICTRANSIT project examines the impact of the ideological transitions in Sicily during the Middle Ages, combining archaeological, molecular, anthropological, ceramics and Isotopic studies. At the confluence of the East, West and Arab world, Sicily had four major changes from Byzantine to Aghlabid to Fatimid to Norman to Swabian. Potentially, each of these transitions brought new networks of exchange, new social rules as well as new groups of migrants with their own genetic patrimony. Objectives: In order to investigate the impact of these different regimes on the medieval Sicilian populations, we apply ancient DNA analysis on 70 human remains spanning the 6th to 13th century from different sites. The aims are to infer population relationship through genome-wide data, to explore the genetic continuity for large-scale populations shifts as well as determining to what extent population affinity is linked to faith-based populations. Methods: We extract DNA from petrous bones or long bones, build double-stranded libraries and sequence them using a whole-genome approach. The proportion of endogenous DNA and assess patterns of authenticity based on sequence length and misincorporation patterns were characterised. We apply the programs LASER (PCAs) and ADMIXTURE to examine the closest related modern population using HGDP dataset. Results: Preliminary data show average fragment length and damage estimates are consistent with an authentic ancient template. The preservation ranges from 0% to at least 30% endogenous DNA. For high-quality samples, a sex identification as well as nuclear data analyses, have been accomplished particularly on two different populations defined by burials rites (Muslim or Christian). Conclusion: New genetic data generated during this ongoing project will be discussed in relation to medieval Sicilian faith-based identity and compare to a modern genomic dataset.
Tracing the Domestication History of the Common Sunflower Using Ancient DNA

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Human-mediated selection transformed the wild sunflower (*Helianthus annuus*) from a highly branching plant with numerous small disks to the domesticated form that exhibits apical dominance and produces large, oil-rich seeds. Although archaeological and genetic evidence suggests domestication occurred in Eastern North America around 4000 years ago, little is known about the pace of selection or the sequence of phenotypic changes. In order to reach new insights into the history of this key oilseed crop, our research team undertook a multidisciplinary investigation of historic specimens and archaeological disks and seeds excavated near the putative domestication centre. By combining radiocarbon dating, morphological measurements, and ancient DNA analyses we track changes in disk size and allele frequencies from 3400 years ago to historic times. We observe morphological changes associated with human selection do not follow a simple trajectory across millennia, but rather indicate a complex path in which a range of disk sizes were maintained by Native American farmers. At the genetic level, we observe archaeological samples originate from the same gene pool as modern landraces; however, our analysis allows us to identify twentieth century genetic introgression from other *Helianthus* species for breeding purposes. Furthermore, whole genome data from ethnographic samples demonstrate that recent breeding has led to a loss of genetic diversity that was present only a century ago in Native American landraces. These results have implications for our understanding of this particular domestication history as well as for sunflower breeding programs.
Soil Interactions and Collagen Preservation in Leather Artefacts from Vindolanda, Northumberland

Hrafnhildur Helga Halldórsdóttir, Dr. Gillian Taylor, Dr. Andrew Birley and Dr. Elizabeth Greene

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This poster presents the first results of an ongoing research project investigating the effect of different soil conditions on protein preservation and degradation in Roman leather artefacts from Vindolanda, a Roman fort site in Northumberland, England. Vindolanda is known for exceptional leather preservation, caused by factors such as atypical soil processes, groundwater activity and repeated sealing of occupation layers with thick clay by past inhabitants. The interaction of these factors has created a variety of waterlogged, anaerobic and microbially complex conditions throughout the site, which appear both in isolation and conjunction with each other, and have produced a range of well-preserved and diverse organic artefacts. This research project will attempt to characterise these different processes and link them to the structural integrity of the leather artefacts that arise from them. Conserved leathers from the site will also be analysed, to evaluate the possible effect of the conservation strategy on the leather structure and future research possibilities. The structural integrity of the leather samples will be determined using amino acid analyses, focusing on the collagen backbone of the leather and compared with the results of non-destructive screening methods, such as Fourier Transform Infrared Spectroscopy (FTIR) and portable X-Ray Fluorescence (p-XRF), to examine their accuracy. The results of this project will contribute to cultural heritage resource management at Vindolanda by providing insight into the processes of protein degradation in different wet soil environments, and the possible implications of different conservation strategies for site-management and interpretation.
Reassessing Calibration of LA-MC-ICP0MS Sr Isotope Analysis of Low Strontium Tooth Enamel

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Variations in the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio in archaeological tooth enamel are regularly used to study past mobility. While removing enamel samples by micro-drilling and analysing the chemically prepared strontium using TIMS is both reliable and accurate, laser ablation-multi collector-inductively coupled plasma-mass spectrometry (LA-MC-ICP-MS) has been proposed, and used to a limited degree and success, as an alternative method for the rapid in-situ analysis of strontium isotopes. However, some studies report the presence of molecular interferences on all the Sr masses, with additional interference in bio-apatites of CaPO$_4$ or ArPO$_4$ on mass 87. This is particularly apparent in low strontium samples, such as enamel, and which cannot be chemically removed during LA-MC-ICP-MS. Without adequate elimination of, and/or correction for these molecular interferences strontium isotope ratios will be artificially high. Human and terrestrial animal tooth enamel typically have very low strontium concentrations (c.50-300ppm), which are considerably below the concentration required to swamp the effect of this interference (c.1900ppm and above). While tuning for low oxides and using a collision cell can limit the formation of certain molecular interferences, this rarely removes them entirely and calibration to a set of preferably matrix-matched reference materials may still be required. Here we present recent work using a calibration set of low [Sr] human tooth enamels previously characterised isotopically by TIMS and investigate whether geogenic apatites can be used, to accurately correct for remaining interferences on mass 87.
16.

Osteoarchaeological Analysis of Cremated Human Remains from Belgium

Elisavet Stamataki¹, Marta Hlad, Christophe Snoeck, Rica Annaert, Mathieu Boudin, Giacomo Capuzzo, Sarah Dalle, Guy de Muller, Ioannis Kontopoulos, Charlotte Sabaux, Kevin Salesse, Amanda Sengeløv, Barbara Veselka, Eugène Warmenbol, Martine Vercauteren and Dries Tys

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The osteoarchaeological study of human remains is crucial to assess age and sex as well as the health status of past population. In the case of cremated remains, this assessment is particularly complex. Within the frame of the CRUMBEL project (Cremation Urns and Mobility in Belgium), the osteoarchaeological study plays a key role. Indeed, cremation was one of the main funeral practices if not the major one in Belgium during the Late Neolithic through to Early Medieval period (up to 700AD). This represents more than 3000 years of Belgian history. The complexity of osteoarchaeological analysis of cremated human remains lies in the high state of fragmentation of the remains and the deformations they underwent during heating (up to 1000°C). Furthermore, the taphonomic damage and post excavation treatment of the remains can erase much of the information present on the bones. This poster presents and discusses the advantages of the methodology used within the CRUMBEL project for the analysis of cremated human remains. Additionally, the impact of the state of preservation of the collection on the obtained results is discussed. In particular, the examination of cremated bones of three Belgian roman collections indicated three different states of preservation that are related to the post depositional processes. The analyses show when sieved and brushed the preservation of osteological information was very poor. However, when the samples received limited cleaning, it was possible to identify age and sex and several individuals as well as some pathologies (osteoarthritis, degenerative disc disease, Schmorl’s nodes, and antemortem tooth loss).
Variation in Bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ of Plant Samples in a Small Urban Wooded Area

Amanda Sengeløv¹, Christophe Snoeck, Rica Annaert, Mathieu Boudin, Giacomo Capuzzo, Sarah Dalle, Guy de Muller, Marta Hlad, Ioannis Kontopoulos, Charlotte Sabaux, Kevin Salesse, Elisavet Stamataki, Dries Tys, Barbara Veselka, Eugène Warmenbol and Martine Vercauteren

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A strontium isotope study was conducted on 60 plant samples from the urban park of Bois de la Cambre (Brussels, Belgium) in order to test the Sr isotope signature variability in a small urban wooded area. The park has a bedrock consisting of three types of sandstone of different ages, which were expected to have different Sr isotope signals. The question rises if, in modern environments, the local signature is predominantly defined by the underlying geology or not. Different types of plant samples, such as grasses, moss, shrubs, trees and nuts, were collected. The $^{87}\text{Sr}/^{86}\text{Sr}$ plant signatures have a mean of 0.71126161 and range from 0.709076 to 0.716230. Three outliers were detected in the data set with significant higher $^{87}\text{Sr}/^{86}\text{Sr}$ signatures. Two of these were moss samples. In general moss samples seem to have higher Sr isotope signatures, which could be caused by a difference in Sr uptake compared to other sampled plants or by contamination by soil or rainwater. Some of the samples were cleaned with Milli-Q water to establish if washing affects the measurements. However, no statistically significant difference was observed. Leaving the outliers aside, the data set has a normal distribution, showing no differences between the five different sample types. However, when comparing the means of the signals of the different sandstones, a statistically significant difference is present. This leads to the conclusion that geology is the foremost influence on Sr isotope signatures, even in a small, man-made setting. These findings will help establishing an appropriate sampling strategy for Sr mapping in densely populated environments such as Belgium.
Investigating the Impact of Faunal Biodiversity on Late Neanderthal and Early Modern Human Behaviour in Britain

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Palaeolithic Britain had a highly variable landscape into which Neanderthal and early modern human groups ventured. Climate during the late middle Palaeolithic was characterised by repeated warm and cold events while the upper Palaeolithic was dominated by the rise and fall of the last glacial maximum. As the north western peninsula of Europe, Britain was at the limit of the hunter-gatherer geographical range and the ultimate test for biological and cultural adaptations. Neanderthal and modern human groups came and went during this time, with long episodes of apparent absence. The archaeological record for this period in Britain is sparse and challenged further by the methods of early excavators and difficulties associated with cave stratigraphy.

Through combining biomolecular (ZooMs, stable isotope and radiocarbon) analyses with traditional zooarchaeological studies at Palaeolithic sites in south and west Britain we aim to provide further insight into the ecological plasticity of hominin groups ranging so far from the heartland of their home range. This approach will significantly increase the available data for faunal presence/absence further understanding of how faunal ecology and migratory behaviour responded to changing environments. Integration of these various streams of archaeological and scientific evidence will test how changes or continuity of faunal biodiversity influenced hunter-gatherer settlement patterns and landscape use, versatility in the landscape, and responses to a variable climate. This poster outlines the project rational, sites under study, methodologies and initial results.
Iso-Biography of the Iron Age Mummied Yingpan Man from the Lop Nor Region of Xinjiang, China

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The discovery of the mummy remains of Yingpan Man provides a unique opportunity for us to build a detailed biographical study about his life history, including his diet, movements and healthy status. Here, 1 bone collagen sample from his patella, 46-cm-long keratin samples from his hair as well as the bulk (n=1) and serial (n=32) dentine samples from his teeth were both selected and isotopically studied. 14 plant samples and 2 animals from Yingpan cemetery were also analyzed to build an environmental baseline for this study. Multiple isotopic analysis (δ¹³C, δ¹⁵N and δ³⁴S) of related bio-tissues as well as starch grain analysis of his teeth were both conducted to investigate how multi-approach captured dietary information which would have been invisible to collagen sample alone. According to the results, seasonal change of consumption on C₃ and C₄ plants were found to be evidential from Yingpan Man’s hair, and this gives us an important clue about the season of his death. Additionally, elevation in δ¹⁵N values of Yingpan samples are extremely illuminating and presented new understandings concerning the living background, dietary emphasis and health conditions of Yingpan Man. Particularly, the comparison of isotopic signal in his bone and teeth are informative of his geological origin and have great potential of reflecting his social identity in Yingpan.
The Study of Mobility in Belgium through the Interpretation of the Burial Landscape and Strontium Isotope Analysis

Sarah Dalle 1, Christophe Snoeck, Rica Annaert, Mathieu Boudin, Giacomo Capuzzo, Marta Hlad, Ioannis Kontopoulos, Charlotte Sabaux, Kevin Salesse, Amanda Sengeløv, Elisavet Stamataki, Dries Tys, Martine Vercauteren, Barbara Veselka, Eugène Warmenbol and Guy de Muller

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Mobility of people has for a long time been harder and slower over land than water in the swampy and forested low countries. Rivers and coastal waters are assumed to have been the highways of communities, connecting people efficiently over longer distances, right until the development of more standardised roads providing a fast and efficient mode of transport. In the Roman period for instance, the road network expanded. As such, places further away from rivers and seas would have become more accessible. Changes in the burial site distribution as a proxy for population density have been observed, suggesting that mobility and landscape exploitation strategies shifted on the long term, following changes in landscape accessibility. Results from strontium isotope analysis and DNA analysis of human remains allow to further explore this hypothesis. However, in Belgium, due to the dominance of cremation as funerary practice from the end of the Neolithic to the start of the Early Medieval period, limited analyses have so far been carried out and DNA results are not available. Through the CRUMBEL project (Cremation, Urns and Mobility in Belgium), several thousands of strontium isotope analyses will be carried out on Belgian cremated human remains. This allows to fully integrate landscape archaeology and mobility studies. Indeed, by temporal and geographical mapping of the strontium isotope data combined with a good understanding of the physical landscape, it is possible to pinpoint and examine shifts in mobility and funerary practices.
Exploring the Potential for Dental Calculus to Reveal New Evidence for Medieval Lifeways

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Recent research has proven that the micro-debris analysis of ancient dental calculus (mineralised plaque) can capture multiple aspects of past lives, including diet, living conditions surrounding environment, evidence of trade. By examining the microscopic particles/debris, both organic and inorganic, that become entrapped in dental calculus through everyday activities, it is possible to gain new insights on multiple aspects of people's lives from the past. It also provides evidence of specific food types or specific features in the environment. This PhD research explores the potential for this microscopic archaeological deposit to provide new evidence for medieval lifeways, focusing on potential variation between different populations living in urban and rural locations and individuals buried at nunnery cemetery sites. This poster showcases the first results from four sites, exploring the data to reveal patterning in micro-debris related to diet, trade/travel, such as evidence of imported crops, and other non-dietary activities of the studied individuals which would not otherwise be available by other bioarchaeological approach. These also include evidence of crafts, such as textile working, as well as variations in surrounding environment, including living environment and surrounding flora.
ArChTES combines Tender-Energy X-ray Absorption Microspectroscopy with stable isotope analyses, to characterise dental enamel during different stages of mineralisation. The study brings together stable isotope signatures with spatially resolved chemical characterisation, to address questions about enamel mineralisation. It provides chemical information critical to answering questions that isotopes alone cannot; and addresses a fundamental limitation of X-ray probes, that they are not sensitive to isotopes. Enamel is well-preserved over long time scales, and is formed at very specific stages of life, thus recording information about not only conditions when and where an animal was alive, but at a particular time in its life. Although enamel of a specific tooth forms at a specific stage of development, and once formed is not altered during life, the sequences and processes of biomineralisation and element incorporation are not uniform during enamel formation. Trace element chemistry and biogenic isotope signatures in enamel have potential to provide information on diet, climate and location. However, better understanding of enamel mineralisation and element inclusion processes is needed to guide sampling, thus enabling greater resolution of the timing of life events. Our study provides the baseline results to enable future work, through linking enamel isotope ratio values and trace element chemistry.
Micromorphological of Textiles Fibres from Experimental Dyeing Vats

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The extent of the textiles industry at Pompeii is debated in current literature. Furthermore, the influence of the kettle, mordant, dyes, yarn thickness, cloth, water, etc is poorly understood. In this study an experimental archaeological replicate of the Pompeii dyeing vats were reproduced. Wool yarn was mordanted with alum, then dyed with fresh birch leaves. Simulation of different metal kettles was then achieved by the additional of metal plates, including copper, lead, oxidised lead and iron. Wool fibres were then measured using high power microscopy and SEM-XRD. Wool sample have been buried in anoxic conditions, where physical and chemical hydrolysis is expected to occur, as the textile is degraded into smaller fragments. Physical biodegradation caused by microorganisms causes disruption of the microstructure which can be seen using the SEM. The first results of this investigation will be presented.
Ancient DNA (aDNA) analysis was carried out to identify the maternal origin of “Lady Takabuti” an ancient Egyptian mummy dating to the 25th Dynasty (c.660 BC). Recent studies performed with a lock of hair through electron microscopy (EM) and Gas chromatography – mass spectrometry (GC-MS) indicated that she is likely a Caucasian individual, based on the cross-section examination. To genetically confirm the hypothesis, a minimally destructive technique was used to obtain biopsy samples from the lumbar vertebrae. Despite the poor starting material, careful sampling and DNA extraction in combination with double mitochondrial DNA enrichment and deep sequencing indicated that she belongs to a rare haplogroup H4a1. Takabuti showed typical H4a1 Single Nucleotide Polymorphisms (SNPs) but she also exhibited an unusual number of variants not known in the human mtDNA phylogeny and are not associated with a specific haplogroup. Here we provide further insights into mitochondrial haplogroup H4 reporting a number of potentially novel SNPs that would possibly contribute to a better understanding of the origins of the H4 haplogroup.
25.

Characterisation of Swedish Steatite via LA-ICP MS, XRD and SEM

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A combination of Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), X-Ray Diffractometry (XRD), and Scanning Electron Microscope (SEM) are being applied to characterise steatite from a variety of locations across Sweden and Norway as phase one of a project aimed at provenancing Viking age steatite objects and gaining a better understanding of their exchange networks. Steatite was used extensively during the Viking age throughout Scandinavia for a variety of household objects. LA-ICP-MS is an analytical tool with an ability to resolve trace elements present in a sample down to parts per billion (ppb) levels. It is especially attractive for archaeological artefacts due to the fact that it can be used on solid objects with little to no sample preparation, does not require a vacuum to operate, and produces minute laser “craters” (5 to 150 µm in diameter) which are invisible to the naked eye. XRD is a rapid analytical technique that can be used to identify crystalline materials and reveal their major element compositions. SEM is used to examine the samples and determine the distribution of the various mineral phases present, the frequency and distribution of which may be characteristic of different source locations. The combination of all three techniques helps to elucidate the differences between steatite from the various quarries sampled, which, in turn, makes it easier to match the artefacts with their sources and thus reveal patterns in trade and transport of such household objects during the Viking Age.
Geoarchaeological Approaches to Pictish Settlement Sites: Assessing Heritage at Risk

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Due to the poor preservation of Pictish Period buildings and the occupation deposits within them, very little is known of daily life in medieval Scotland. In lowland and coastal areas, Pictish buildings are generally truncated by deep ploughing (e.g. Rhynie, Clarkly Hill), coastal erosion (e.g. Dunnicaer) or urban development (e.g. Burghead), while those uncovered in upland areas seem to have no preserved floor deposits for reasons that are yet to be understood (e.g. Lair in Glenshee). Geoarchaeological techniques clarify site formation processes and are a powerful research tool for identifying floor deposits, distinguishing their composition and linking this to post-depositional events. However, these techniques have not yet been applied to Pictish Period dwellings.

This presentation will therefore showcase a new study aimed at elucidating site formation processes on Pictish settlement sites and channelling these results directly into cultural heritage management frameworks. Through a combined programme of geoarchaeological analysis, re-excavation and stakeholder engagement, this project aims to identify what the major risks are to Pictish settlement sites now and in the future. This will help guide conservation and management solutions whilst assessing the research potential of fragmentary buildings if analysed using geoarchaeological methods. Proposed outcomes include an assessment-of-risk report, accompanying risk map and practical guidelines on how and when to take different types of geoarchaeological samples.
From Rural Production to Relational Landscapes: A Technological Reassessment of Indus Ceramic from NW India

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This paper will present preliminary results of ceramic analysis on assemblages from excavations at Masudpur I and Lohari Ragh I, Haryana, North-Western India. These results are part of a PhD research project that aims to trace phenomena of social reproduction and changes in Bronze Age South Asian villages through a technological and compositional study of Indus ceramics. In this study, morpho-stylistic and scientific analysis are undertaken to explore craft traditions within rural communities, where technological variability and the full trajectory of chaînes opératoire for the production of a large variety of ceramic artefacts are identified. Technological traditions are here presented as a medium for understanding the synchronic relationship among Indus villages, communities’ networks, and diachronic transmission of knowledge. After providing an overview of the project’s methodology, the ceramic traditions identified at these sites will be introduced.
28.

Stable Isotope Evidence for Pre-Columbian Diet in the Amazon Coast of Brazil

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Archaeological investigations in lowland South America are radically transforming our understanding of human-environment interactions in the Neotropics, and challenging the traditional view that some regions, such as the Amazon basin and surrounding areas, had witnessed limited societal development in pre-Columbian times. Nevertheless, considerable uncertainties still exist regarding the extent that Amazonian societies integrated plant cultivation and exploitation of wild resources, and the role of agriculture in supporting population growth, geographic dispersal, and the establishment of sedentary villages in more recent pre-Columbian times. Here we offer a novel contribution to highlight pre-Columbian diets in lowland Amazon basin. We analyzed the stable carbon and nitrogen isotope composition of human individuals from ceramic sites on São Luís island (Maranhão, N. Brazil). Most of the individuals were directly radiocarbon dated (AMS) between ca. 1800 to 1000 cal BP and were recovered from archaeological contexts associated with ceramic traditions similar to Amazonian complexes. Faunal remains found at one site were analyzed to establish local isotopic baselines. Modern plants, including major neotropical crops such as manioc (Manihot esculenta), sweet potato (Ipomoea batatas), and maize (Zea maize), were obtained from local markets and analyzed for their stable carbon and nitrogen isotope composition. Bayesian Mixing Model was used for estimating the proportional contribution of marine and terrestrial resources to dietary calories and proteins, and to correct the effect of marine carbon to individual ¹⁴C ages. To the best of our knowledge, the results presented here are currently the most direct and chronologically secure sources of individual diet in pre-Columbian Amazon.
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