Radiocarbon & Diet 2

Aarhus, June 20-23, 2017

Book of abstracts

http://conferences.au.dk/radiocarbonanddiet2017 radiocarbonDiet17@phys.au.dk

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AARAMS - Aarhus AMS Centre
Department of Physics and Astronomy, Aarhus University

Contents

Welcome

Dear friends and colleagues,

It is a great pleasure to welcome you here in Aarhus as attendees of the 2nd Radiocarbon and Diet Conference.

The idea with this meeting is to bring together experts from diverse research fields to encourage interdisciplinary discussions and to inspire a critical dialogue between the different research fields with the aim to enrich and enhance radiocarbon and dietary studies. We are looking forward with excitement to three great days here in Aarhus.

Furthermore, we hope you may find time to enjoy a little of Aarhus - the European culture capital 2017 - while you are here. We will do our best to guide and help you with enquiries you may have during your stay with us.

Welcome to Aarhus and the 2nd Radiocarbon and Diet Conference.

Sincerely,

The organising committee (Jesper, Marie, Bente and Mette)

Sponsors

Organizing committee

	Jesper Olsen Aarhus AMS Centre (AARAMS) Department of Physics and Astronomy Ny Munkegade 120 DK-8000 Aarhus C jesper.olsen@phys.au.dk
	Marie Kanstrup Aarhus AMS Centre (AARAMS) Department of Physics and Astronomy Ny Munkegade 120 DK-8000 Aarhus C maka@phys.au.dk
	Bente Philippsen Aarhus AMS Centre (AARAMS) Department of Physics and Astronomy Ny Munkegade 120 DK-8000 Aarhus C bphilipp@phys.au.dk
	Mette Alstrup Lie Aarhus AMS Centre (AARAMS) Department of Physics and Astronomy Ny Munkegade 120 DK-8000 Aarhus C lie@phys.au.dk

Scientific committee

Philippa Ascough, University of Glasgow (SUERC)

Elisabetta Boaretto, Weizmann Institute

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Jesper Olsen, Aarhus University

Bente Philippsen, Aarhus University

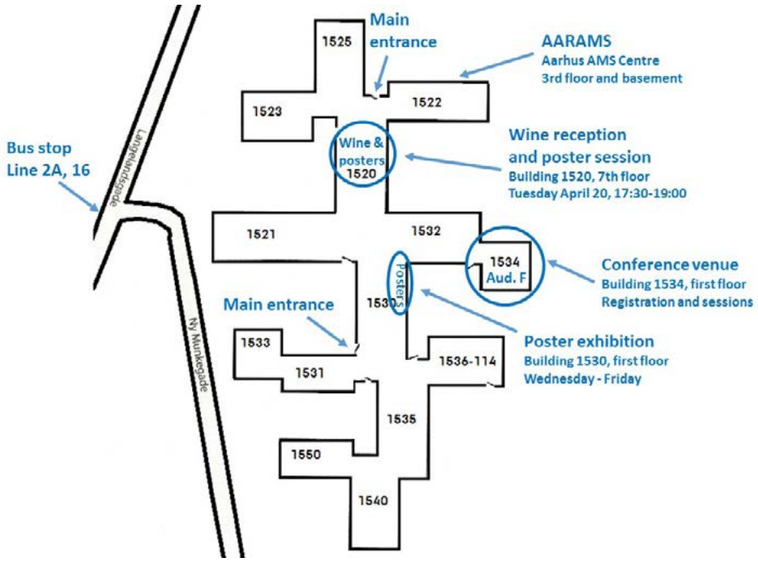
Felix Riede, Aarhus University

Laura van der Sluis, Queen's University Belfast

Svetlana Syvatko, Queen's University Belfast

Venue

The conference will take place in Auditorium F on the main campus – which is easily recognizable, with its yellow brick buildings in the University Park. On the building map you can search for buildings or people, and find an overview map of the campus. The University Park offers nice spots for enjoying the lunch break, as well as three museums (Natural History, History of Science and Medicine, and Museum of Ancient Art). Find out more here.



Access to wireless network

At Aarhus University you may access WiFi using your Eduroam account.

If you do not have an Eduroam account you can access the Wi-Fi network AU-Guest.

How to access the AU-Guest network

You must log in by using your

- Microsoft
- LinkedIn
- Google
- Facebook

If the you do not have such an account, the you can receive an SMS with a code on your mobile phone, provided that you have a Danish mobile number.

Presentation guidelines

Oral presentations

Oral presentations are 20 minutes (15 minutes presentation/ 5 minutes for questions).

Please make sure to keep time.

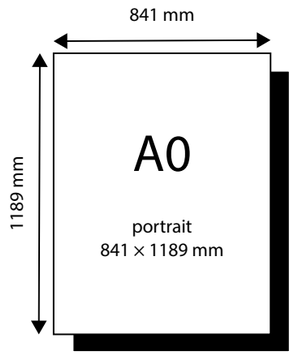
Microsoft Powerpoint and Adobe Acrobat can be used for presentation

Presentations should be uploaded at latest in the break prior to the session

Poster presentation

The poster size should not exceed A0 (841 x 1189 mm).

The posters will be presented throughout the meeting duration



Publication of conference proceedings

The proceedings of the conference will be published in a special volume in Radiocarbon named: Proceedings of "Radiocarbon and Diet: Aquatic Food Resources and Reservoir Effects" Second International Conference, 20-23 June 2017, Aarhus, Denmark.

Contributions should not exceed more than 8 printed pages.

Submission deadline for contribution: September 15th 2017

Expected deadline for accepting papers: November 15th 2017

Expected publication date: in or before Octorber 2018

Radiocarbon
An International Journal of
Cosmogenic Isotope Research

The University of Arizona
Department of Geosciences
4717 E. Fort Lowell Road, Rm. 104
Tucson, AZ 85712-1201 USA

Fax: +1 520 621-0584
Tel: +1 520 621-0641
jull@email.arizona.edu
kimelliott@email.arizona.edu
www.radiocarbon.org

A.J.T. Jull, Editor
Kimberley T. Elliott, Managing Editor

A Note about the Proceedings

Any paper or poster presented at the 2nd International Radiocarbon and Diet Symposium (Aarhus, Denmark, June 20–23, 2017) can be submitted for publication in the Proceedings.

The Proceedings will be published in the journal *Radiocarbon* (radiocarbon.org). As with all papers in *Radiocarbon*, the Proceedings will be peer-reviewed. The published papers will also appear online via *Radiocarbon*'s Cambridge Core site (http://journals.cambridge.org/RDC).

Authors will be provided with online access codes to their papers when each is published online. A printed copy of the complete issue can be purchased (subject to availability) through the journal's publisher, Cambridge University Press (cindy.eyler@sheridan.com).

The Proceedings should be published before the end of 2018. More details will be provided upon submission of a manuscript. Please contact Managing Editor Kimberley Elliott at kimelliott@email.arizona.edu or Editor in Chief Tim Jull at jull@email.arizona.edu if you have any questions. We look forward to working with you.

Submitting Your Manuscript

Authors will submit their papers via *Radiocarbon*'s online manuscript management site, https://mc.manuscriptcentral.com/rdc. The Author's submission page features a pull-down list of article types. To ensure proper issue assignment, please scroll down and select Type "2017 C-14 in Diet Conf. Paper" for this Proceedings issue.

For style and formatting guidelines, please carefully follow the Instructions for Contributors, available online at Cambridge Core, http://journals.cambridge.org/RDC.

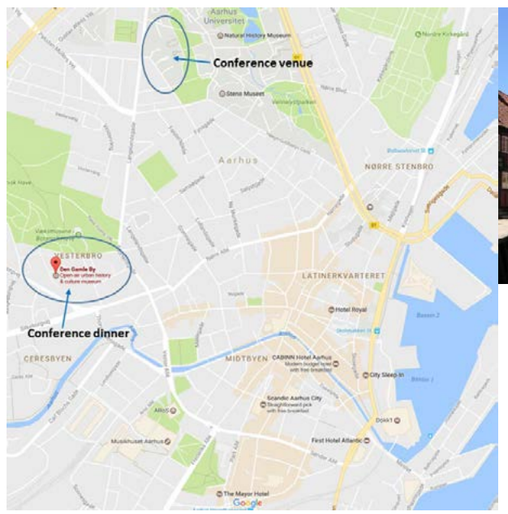
Please note: Proceedings articles will be published free of charge to participants, but length restrictions will apply. Therefore, free papers will be limited to approximately 4500 words (about 15 manuscript pages) and 4 figures. Authors whose papers exceed the limit will be asked to pay page charges of $50 per printed page for the excess pages.

Submission deadline: Sept. 15, 2017
Review deadline: Nov. 15, 2017
Publication date: in or before Oct. 2018

Social events

Conference Dinner

Thursday 1900 - c. 2200, June 22nd.



Møntmestergården
Den Gamle By

Viborgvej 2
8000 Aarhus C

Wine reception and poster session

Department of Physics and Astronomy
Ny Munkegade 120
DK-8000 Aarhus C

The reception will take place at the 7th floor. Please remember your name tag in order to access the building

Exploring Aarhus

In the case of nice weather, we'll suggest you to take a walk along the harbor and beaches, exploring the newly constructed quarter Aarhus Ø and the open-air art exhibition The Garden - The Future. If you continue through the beech forests by the sea for about 6km (or take bus nr. 18), you'll reach Moesgård Museum, a newly-built museum of Prehistory, Ethnography and Anthropology. In the city centre, you'll find ARoS (Museum of Contemporary Art), a Viking Museum in the basement of a bank, and many other big and small attractions. Take a look at VisitAarhus to find the attractions and activities that interest you!

European capital of culture

In 2017, Aarhus is European Capital of Culture. As it is impossible for us to list all the exciting events, please visit Aarhus-2017 to find out what's going on during the week of the conference.

Getting around in Aarhus

From the hotels in the city centre, all conference venues within easy walking distance. You can also borrow a free "bycykel" (city bike) for a deposit of 20 DKK, or rent a bike. Several busses connect the city centre with the university. A single-ride ticket costs 20 DKK. Please visit MidtTrafik for information about ticket prices and a travel planner

Lab tour at AARAMS

Wednesday 15:00 - 16:00, June 21st.

Sign up at the registration desk for the guided tour at the Aarhus AMS Centre (AARAMS).

Department of Physics and Astronomy
Ny Munkegade 120
DK-8000 Aarhus C

IsoMemo workshop

Isotopic tracers are used across a variety of research fields to provide a rich diversity of scientific information, but the lack of centralized storage limits the efficient data use. To overcome this deficiency, the partnership-based initiative IsoMemo was started. IsoMemo brings together research groups and databases of stable and radioactive isotopes within the fields of archaeology, environmental and life sciences.

During the workshop, an overview will be given on the current status of the IsoMemo initiative. In addition, three IsoMemo partners (Royal Institute for Cultural Heritage Web-Based Radiocarbon Database, IsoArcH, and OASIS and δIANA) will give short presentations on the status of their respective databases. Following this, there will be an open discussion period where different topics concerning the initiate will be discussed. These will include:

- Defining common data standards
- Building user-friendly interfaces
- How to ensure data quality
- Collaborative projects and funding
- How to promote data sharing while acknowledging data makers

Scientific program (overview)

Time	Session	Session chair
Tuesday		
13:00 – 1310	Welcome	Jesper Olsen
13:10 – 14:00	Keynote 1	Jesper Olsen
14:00 – 14:40	Session 2A	Marcello A. Mannino, Laura G. van der Sluis
14:40 – 15:10	Coffee and tea	
15:10 – 16:50	Session 2B Session 3A Session 3C	Jesper Olsen, Jan Heinemeier, Jette Arneborg
Wednesday		
9:00 – 9:50	Keynote 2	Marie Kanstrup
9:50 – 10:15	Coffee and tea	
10:15 – 11:55	Session 3C	Yaroslav Kuzmin, Ricardo Fernandes, Svetlana Svyatko
11:55 – 13:00	Lunch	
13:00 – 14:50	Session 3C	Yaroslav Kuzmin, Ricardo Fernandes, Svetlana Svyatko
14:40 – 15:10	Coffee and tea	
Thursday		
9:00 – 9:50	Keynote 3	Bente Philippsen
9:50 – 10:15	Coffee and tea	
10:15 – 11:55	Session 1A Session 1B Session 1C	Ricardo Fernandes, Andrew Millard
11:55 – 13:00	Lunch	
13:00 – 14:50	Session 1C Session 4A	John Meadows, Linda Cummings
14:50 – 15:10	Coffee and tea	
15:10 – 17:10	Session 4A Session 4B	John Meadows, Linda Cummings
Friday		
9:00 – 9:50	Keynote 4	Jesper Olsen
9:50 – 10:15	Coffee and tea	
10:15 – 11:35	Session 4B	Marie Kanstrup, Bente Philippsen
11:35 – 12:30	Business meeting	Jesper Olsen

	Tuesday 20th	Wednesday 21st	Thursday 22nd	Friday 23rd
9^{00} – 9^{50}	Registration opens at 9^{00}	Keynote: **Rick Schulting**, University of Oxford	**Keynote: Matthew Collins,** University of York / University of Copenhagen	**Keynote: Nichola Whitehouse**, Plymouth University
9^{50} - 10^{20}		Coffee and tea	Coffee and tea	Coffee and tea
10^{20} - 12^{00}		**Session 3C**: *Palaeodiet in Northern Eurasia: New Results from Stable Isotope Studies*	**Session 1A**: *Compound specific radiocarbon determination* **Session 1B**: *Compound-specific stable isotope analysis for palaeodietary reconstruction* **Session 1C**: *Human and animal diet reconstruction using numerical methods*	**Session 4B**: *Palaeodiet reconstructions and chronologies*
12^{00} - 13^{00}		Lunch break	Lunch break	Business meting *Bids for hosting next meting* *Publication in special volume (Radiocarbon)* *When is the next meting?*
13^{00} - 14^{40}	Welcome **Keynote: Julia Lee-Thorp**, University of Oxford. **Session 2A**: *Baseline data: radiocarbon dating and stable isotope studies of potential food resources*	**Session 3C**: *Palaeodiet in Northern Eurasia: New Results from Stable Isotope Studies*	**Session 1C**: *Human and animal diet reconstruction using numerical methods*	
14^{40} - 15^{10}	Coffee and tea		Coffee and tea	
15^{10} - 16^{50}	**Session 2B**: *The marine reservoir effect: complex issues and current challenges* **Session 3A**: *Paleodiet reconstructions and chronologies in Arctic regions* **Session 3C**: *Palaeodiet in Northern Eurasia: New Results from Stable Isotope Studies*	Enjoy Aarhus on your own 15^{00} – 16^{00} Lab tour at AARAMS **IsoMemo workshop**	**Session 4A**: *Amorphous food remains – radiocarbon dating and paleodiet reconstruction* **Session 4B**: *Palaeodiet reconstructions and chronologies*	
	17^{30} – 19^{00} Wine reception and poster session Department of Physics and Astronomy 7th floor		19^{00} Conference dinner at Møntmester Gården, Den gamle By	

Scientific program (detailed)

Keynote Speakers

Tuesday June 20th 13:10 - 14:00

Forays into the 'C4 world'

Julia Lee-Thorp, University of Oxford.
School of Archaeology, University of Oxford

Reliance on wild or domesticated C4 resources in contrast to C3 elements is relatively straightforward matter to detect from carbon isotope ratios in bones and teeth because of the sharp distinction in carbon isotope values between the two photosynthetic pathways. Additionally, C4 plants are restricted to grasses and certain sedges unlike C3 plants so in many circumstances we may be able to derive further information about subsistence patterns. Carbon isotope ratio analysis has now been widely applied, both to tooth enamel in fossils, and in the more recent past, in bone collagen. As it is now understood, adoption of C4 plants as staples has been fairly rare in human evolutionary and archaeological history. I argue here that the largest human subsistence shifts into the 'C4 world' are those that directly involve consumption of grasses or cereals. In the Plio-Pleistocene carbon isotopes in fossil hominin tooth enamel document increasing amounts of C4-based resources in the diet, culminating in an almost complete reliance by ca. 1.8Ma in Paranthropus boisei. This finding is astonishing given that no other primates are known to rely much on C4 at all. This level of reliance was not found again until the domestication of maize several thousand years ago and its wholesale adoption as a staple in many parts of the Americas, and eventually other parts of the globe. Domesticated C4 millets in Asia and Africa did not reach the same level of reliance. Much of the impact of C4 crops today are not necessarily by direct consumption but in the form of animal feed and the ubiquitous processed high fructose corn syrup or cane sugar, now widely believed to be responsible for the current obesity crisis in industrial countries.

Wednesday June 21st 09:00 - 09:50

The problems caused by people consuming foods past their sell-by date

Rick Schulting, University of Oxford
School of Archaeology, University of Oxford

The problems for the radiocarbon dating of archaeological human remains caused by 'old carbon' reservoirs have long been known, but their full extent and importance has only slowly become fully appreciated. This is particularly so for freshwater reservoir offsets, which are proving to be extremely variable, and can often have a much greater effect than marine systems. Clearly we would like to be able to use dietary proxies to estimate the contribution of foods with a ^{14}C reservoir offset. Stable carbon and nitrogen isotopes remains the most widely used for this purpose, though other isotopes such as sulphur and hydrogen may also be useful in certain contexts. This presentation reviews a number of archaeological case studies attempting to correct for reservoir offsets in both marine and freshwater systems, ranging from those that proved very successful, to those with some rather surprising results.

Detecting archaeological collagen

Matthew Collins, University of York / University of Copenhagen

Department of Archaeology University of York, Chair of Palaeoproteomics, Copenhagen University.

In this presentation I will attempt to answer a question once posed to me by the late Geoffrey Eglinton; what actually is archaeological collagen? Collagen is ubiquitous in bone and is the primary protein used in both radiocarbon dating and isotope analysis. Its widespread utility in archaeology stems from its rather unusual properties, a highly repetitive, mineralized fibrous protein. What do we know and still not know about how collagen decays, and does any of this matter? Advances in protein mass spectrometry have opened up a number of new avenues for archaeologists. I will focus primarily on the new insights gained by these new approaches to study and characterise collagen. I will discuss the application of bone collagen to identify bone fragments (ZooMS) and explore what we are beginning to learn about protein decay. I will then consider how these findings may impact upon our decisions to select and prepare collagen for radiocarbon dating and stable isotope analysis.

A time and place for everything; prehistoric land-use history and food production in early agricultural societies

Nichola Whitehouse, Plymouth University

School of Geography, Earth and Environmental Sciences, Plymouth University, Drake Circus, Plymouth, PL4 8AA, England, UK.

The transition to agriculture and the dietary opportunities afforded by this represents a major factor in Holocene global landscape change and signalled the start of many key cultural developments across many regions of Europe and elsewhere. The landscape consequences of this major shift in subsistence strategy also likely played an important role in the onset of many of the major environmental and climatic challenges we now face. Consequently, there is now a global level effort to develop an integrated understanding of prehistoric land-use history, relationships to food production and effects on biophysical systems.

An evaluation of the ecological and biochemical transformations associated with early agriculture is presented, starting from a broad perspective gained from European palaeoecological, archaeological, sedimentary nitrogen isotopes and modelled vegetational data, then focusing on a case study region from Neolithic Ireland. Here, detailed spatial and temporal analyses using Bayesian chronological approaches have been undertaken on 72 pollen sites. The timing of vegetational events of interest and their relationship to human activities and early agriculture is examined, allowing an exploration of the timing of spatial expansion and contraction of selected taxa across the study region. Pollen modelling using REVEALS approaches examines the broader trends in spatial-temporal landscape open-ness and provides preliminary land cover maps for the region. Palaeoecological data are compared with 14C, archaeological settlement and archaeobotanical data to understand the relationships between landscapes and agricultural practises, the nature and mode of food production, the use of wild resources and land use.

Differences between pollen and plant macro-remains records are likely related to the catchment of pollen signatures and the context of archaeobotanical records and differences in the use of the landscape. Many early agricultural sites were located along in-land fluvial routes, on good agricultural lands, with highly productive, well-drained soils. This suggests targeted use of resources by groups of people with an intimate knowledge of agricultural systems. Other landscape areas were clearly under-utilised, however, suggesting considerable variation in landscape open-ness at a broad geographic scale. A consideration of how changing forest canopy openings, land use and subsistence strategies impacted biochemical signatures in human, animal and natural ecosystems is also provided. Finally, the spatial and chronological challenges associated with comparing large and very diverse datasets, with differing levels of chronological precision and representing different behaviour patterns, are discussed.

SESSION 2A, Tuesday June 20th

Environmental context

Baseline data: radiocarbon dating and stable isotope studies of potential food resources

Organised by: Marcello A. Mannino, Neeke Hammers and Laura G. van der Sluis

Accurate diet reconstruction is only possible if the baseline data is well established. Therefore, analyses of potential food plants and animals from the study region are an essential prerequisite for palaeodiet studies. Anthropogenic changes in the environment such as wood clearance or manuring can change the baseline data and make palaeodiet studies more complex. Furthermore, environment and diet can change during an individual's lifetime and those changes can be detected in growth increments in human or animal bones or mollusk shells.

This session welcomes contributions that establish isotopic baselines or measure radiocarbon reservoir ages of food resources. We welcome case studies on archaeological or modern samples as well as studies that explore the temporal and spatial variability of isotope ratios or radiocarbon reservoir effects.

Isotopic and radiocarbon investigation of a Late Medieval mass grave from Aalborg (Denmark)

Marcello Antonio Mannino[1,2], S Østergaard[3], M Kanstrup[4], S Talamo[2], EK Enggaard Jørgensen[1], S Bergmann Møller[5], B Springborg[5], ML Schjellerup Jørkov[6], N Lynnerup[6], J Olsen[4]

[1] Department of Archaeology and Heritage Studies, School of Culture and Society, Aarhus University, Højbjerg, Denmark
[2] Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany
[3] Department of Archaeological Science and Conservation, Moesgaard Museum, Højbjerg, Denmark
[4] Aarhus AMS Centre, Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark
[5] Nordjyllands Historiske Museum, Aalborg, Denmark
[6] Department of Forensic Medicine, University of Copenhagen, Copenhagen, Denmark

Excavations in the churchyard of the former Church of Saint Peter in Aalborg unearthed 33 burials and skeletal remains of 18 individuals from a mass grave of Late Medieval age. The physical anthropology and archaeological context of the osteological remains suggest that the common burial may have been dug to deal with the death toll resulting from the incursion by the troops of King Christian III, which took place in 1534, as part of the conflict known as the Count's Feud. Human bone collagen extracted from individuals from the mass grave has been AMS radiocarbon dated and the results support its attribution to the above-mentioned 'storming of Aalborg'. Moreover, the bones from the common burial have isotopic ratios that overlap with those of the ordinarily inhumated people, suggesting that the diets of all those buried around Saint Peter's church were based mainly on terrestrial foods, but included significant amounts of protein from marine fish (e.g. herring). The dietary contribution of the latter will be estimated through Bayesian mixing models and by taking into account the radiocarbon offsets from the expected age. However, the dietary mix of the individuals from the mass grave was different from that of other Late Medieval north European groups, suggesting that the victims were local rebels rather than foreign mercenary soldiers.

From oysters to cockles at Hjarnø: chronology and economy on a Mesolithic kitchenmidden site

Bente Philippsen[1,2], J Sandvang Larsen[3], C Skriver[4], P Moe Astrup[4], P Borup[5], J Olsen[1], MA Mannino[6,7]

[1] Aarhus AMS Centre, Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark
[2] AU STAR Network (Science and Technology in Archaeological Research), Department of Archaeology, Aarhus University, Højbjerg, Denmark
[3] Department of Medieval- and Renaissance Archaeology, Aarhus University, Højbjerg, Denmark
[4] Moesgaard Museum, Department of Archaeology, Højbjerg, Denmark
[5] Horsens Museum, Horsens, Denmark
[6] Department of Archaeology and Heritage Studies, School of Culture and Society, Aarhus University, Højbjerg, Denmark
[7] Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

At Hjarnø, an island in Horsens fjord (Denmark), a submerged Mesolithic settlement has been known since at least 1936. In 2010 and 2011, a refuse layer of the former settlement was excavated. Despite the threat of erosion, organic preservation was generally good. For example, fragments of paddles with remains of painted decorations were found. In 2015, a shell layer at the site, facing imminent destruction by waves, was sampled. In total, 8 large boxes of shells were collected, one from each of the 1m² squares.

A sample of ca. 18.000 shells NISP (ca. 3000 MNI) from the eight squares was identified to species. Of these, a subsample of 780 cockles and 115 oysters were measured. Preliminary results show that oysters became on average larger and cockles smaller moving up the sequence, as the species dominating the assemblages shifted from oysters to cockles. Overall, several lines of evidence, including the taphonomy of the shells, suggest that the shell accumulation is anthropogenic.

Radiocarbon dates of associated shell and charcoal samples were used to calculate the local reservoir effect and to establish the chronology of the shell midden. Interestingly, our results indicate that the change in dominant species, from oysters to cockles, happened at about 5300 cal BC. The orthodoxy is that this shift in mollusc species occurred at 4000 cal BC and a hypothesis for the introduction of the Neolithic economy was partly driven by 'the oyster decline'. We will also present $\delta^{13}C$ and $\delta^{18}O$ measurements on CO_2 subsamples from the shells, which will enable us to study the marine environment in more detail.

SESSION 2B, Tuesday June 20th

Environmental context

The marine reservoir effect: complex issues and current challenges

Organized by: Jesper Olsen and Philippa Ascough

The marine reservoir effect is a highly complex issue in fjords, estuaries or inland seas such as the above-mentioned Baltic. Changes in ocean currents or climate can cause variations of the marine reservoir effect. Marine resources consumed by humans can originate from different marine environments or different water depths, resulting in different reservoir effects in the food sources. This session invites studies that quantify the marine reservoir effect, reconstruct complex marine-based diets or use marine reservoir effects as a marker for marine nutrition.

A palaeodietary investigation using human and animal bones from the Limfjord – exploring the use of hydrogen stable isotope ratios to estimate marine protein intake for radiocarbon calibration

Laura van der Sluis, P Reimer, N Ogle

Queen's University Belfast, School of Natural and Built Environment, Belfast, UK

The Limfjord region in northern Jutland, Denmark, has a rich archaeological heritage dating from the Mesolithic to the Medieval periods. Prehistoric bone from humans and animals was subjected to carbon, nitrogen and hydrogen stable isotope analysis to infer past consumed diet. As the bone material originates from sites from the Mesolithic (4000 cal. BC) up to the Viking Age (1050 cal. AD), covering a time span of 5000 years, this enabled us to examine dietary changes through time. The results suggest a factor other than diet is influencing the nitrogen stable isotope ratios in human individuals from the Iron Age, which is most likely caused by manuring.

Carbon and occasionally nitrogen stable isotope ratios are used to estimate marine protein in the diet for calibration of radiocarbon ages. However, carbon stable isotope ratios can be influenced by freshwater input or C_4 plants, such as millet or maize, in the diet. In addition, consumption of marine resources can be less obvious in a low-protein diet, resulting in less enriched isotopic values than expected. Nitrogen stable isotopes similarly have their limitations, as they can be influenced by a range of factors, such as manuring and aridity. As such, hydrogen stable isotope ratios might serve as a useful tool to estimate marine dietary input for calibration of 14C ages.

In addition to 267 samples analysed for carbon and nitrogen stable isotopes, there were 13 samples from various prehistoric time periods for which the 14C ages and hydrogen stable isotope ratios were available. The calculated amounts of marine intake differ between the usage of carbon and hydrogen stable isotope ratios, although there are no major differences in the outcome (archaeological periods), which is possibly related to the moderate correlation between the two isotopes but most likely the large uncertainty in ΔR also played a role. Perhaps the most advantageous result is the lack of negative numbers in the calculated amount of marine protein in the diet using hydrogen stable isotope ratios. It would be worthwhile to test this on material from a region with smaller ΔR uncertainty.

Marine radiocarbon reservoir age of the coralline rhodophyte alga lithophyllum byssoides in the Mediterranean

Sanja Faivre[1], T Bakran-Petricioli[2], J Barešić[3], D Borković[3], D Horvatić[4]

[1] University of Zagreb, Faculty of Sceince, Department of Geography, Zagreb, Croatia
[2] University of Zagreb, Faculty of Sceince, Department of Biology, Zagreb, Croatia
[3] Ruđer Bošković Institute, Radiocarbon Laboratory, Zagreb, Croatia
[4] University of Zagreb, Faculty of Science, Department of Physics, Zagreb, Croatia

Coralline algae are very important framework builders outside the coral-reef belt and therefore they could provide very important records on palaeoclimate and palaeoenvironment. This archive, even though recently underutilized, has the potential to fill the gap left by the spatially restricted occurrence of reef-building coral proxy archives. Moreover, algal rims created by Lithophyllum byssoides are very precise sea-level markers (±10cm) in the microtidal environment because the life range of the alga relates directly to the tide. This perfect relative sea-level marker is constrained by its marine radiocarbon reservoir age (MRE) which is not known. Highly accurate age determination is a principal procedure in the research of past global environmental changes, which can further allow a realistic prediction of changes in the future. In palaeo-sea-level research, the late Holocene is the most intensively studied period, which, due to its brevity, requires even more precision and accuracy. Previously, it was assumed that alga L. byssoides does not have any marine radiocarbon reservoir effect. This assumption was based on dating of living thalli. However, recently, researches have also corrected algal 14C data with global means. Working with very short time-scales (e.g. a period of 2 ka) we observed that young samples can't be corrected with global means. Therefore, here we provide evidence for the algal MRE based on algal samples of known age obtained from the Natural History Museums in Paris, Vienna and Hamburg. The algae used for 14C dating were collected from AD 1858 to 1913 and represent the pre-bomb period. 8 samples are from the Mediterranean while 1 sample is from the Atlantic. We applied radiocarbon dating of marine material with a known calendar date of death of the organism. This approach enables a comparison of contemporaneous atmospheric and marine radiocarbon ages. The deficiency in 14C content of the measured marine sample relative to the global atmospheric calibration curve is then used to calculate the "apparent age" of the material. The weighted mean was calculated using only the Mediterranean samples even though the use of the Atlantic sample would not have changed the final result. We also used palaeo data from 9 Eastern Adriatic algal rims from which we obtained more than 100 algal radiocarbon and stable isotope (δ^{180} and $\delta^{13}C$) records. Based on those records we provide several lines of evidence that the alga which lives in the intertidal zone has a lower marine radiocarbon reservoir age than the mean surface water MRE, while, on the other hand, shells (mytilid bivalves) which usually live in the biogenic rims have higher reservoir ages than global means.

This research was supported by the Croatian Science Foundation (project no. HRZZ-IP-11-2013-1623, Reconstruction of the Quaternary environment in Croatia using isotope methods – REQUENCRIM) and by the University of Zagreb Supports for 2013 (no. 4.1.1.28), 2014 (no. IP2.4) and 2015 (no. IP003). We would also like to express our gratitude to the Muséum National d'Histoire Naturelle in Paris, especially to Bruno de Reviers, for providing algal samples from its collections for this research, as well as to Christophe Morhange for help-

ing us in that regard. We also thank the Universität Hamburg, Biozentrum Klein Flottbek und Botanischer Garten, Dr. Matthias Schultz (curator at Herbarium Hamburgense) as well as the Naturhistorisches Museum, Wien, Dr. Anton Igersheim (Curator of the Cryptogamic Collection) both of which kindly provided samples without which this study could not be effectuated.

SESSION 3A, Tuesday June 20th

Regional applications

Paleodiet reconstructions and chronologies in Arctic regions

Organized by: Jan Heinemeier and Jette Arneborg

Chronologies of past human activity in Arctic regions are often complicated by marine and freshwater reservoir effects. This session will focus on stable isotope diet reconstructions and their usage for correcting radiocarbon chronologies in Arctic regions.

Reservoir correction of radiocarbon dates on bones from pagan and early Christian graves in Iceland based on dietary reconstruction

Árný E Sveinbjörnsdóttir[1], J Heinemeier[2], J Arneborg[3], N Lynnerup[4]

[1] Institute of Earth Sciences, University of Iceland, Reykjavík, Iceland
[2] The AMS 14C Dating Laboratory, University of Aarhus, Aarhus, Denmark
[3] Laboratory of Biological Anthropology, Panum Institute, Copenhagen, Denmark
[4] National Museum of Denmark, Copenhagen, Denmark

In this study, $\delta^{13}C$ and $\delta^{15}N$ of bone samples from 83 skeletons (79 humans, 2 horses, and 2 dogs) excavated from pagan and early Christian graves from 21 localities in Iceland are used to reconstruct diet of the early settlers of Iceland and possible differences in diet depending on the distance between the excavation site and the seashore. Human bones show large variation in $\delta^{13}C$ values (-16.4‰ to -20.3‰ VPDP) although most of the data lie in the range of about -18‰ to -20‰. The dogs and horses analysed show $\delta^{13}C$ of about -16‰ and -22‰, respectively. $\delta^{15}N$ measurements of the human bones lie in the range 6.5‰ to 15.5‰ and a general trend is observed between $\delta^{15}N$ and $\delta^{13}C$, where bone collagen with the lowest $\delta^{13}C$ also shows the lowest $\delta^{15}N$ and vice versa. While the $\delta^{13}C$ values of bone collagen reflect the fraction of marine carbon in diet, the $\delta^{15}N$ values are believed to give information on trophic level of the food, i.e. the position in the food chain. The measured $\delta^{13}C$ of the bone samples is used to estimate and correct for the marine reservoir effect (the 14C difference between terrestrial and mixed marine organism) on the radiocarbon ages. The reservoir corrected ages lie in the range AD 780-1270 (68.2% probability). Reservoir age correction were checked by comparing 14C dates of a horse (terrestrial diet), a dog (highly marine diet) and a human (mixed diet) from the same burial. The range in measured marine protein percentage in individual diet is found to range from about 10% up to 55%, mostly depending on the geographical position (distance from the sea) of the excavation site. The gravesites at the seashore show extreme variation in $\delta^{13}C$ from -19.7‰ to -16.4‰, with the mean value of -17.94±0.95‰, while much smaller range is observed from the individuals living inland (-20.1‰ to -19.2‰) with a mean value of -19.66±0.24‰. This difference probably is due to the fact that people living at the seashore had the choice between marine food and agricultural products, whereas people living inland had poor access to the sea and were forced to subsist mainly on agricultural products. No evolution in food consumption is found with time over the period studied. Systematic difference in subsistence can neither be isolated as reflecting cultural differences (pagan vs Christian) nor social hierarchy.

SESSION 3C, Tuesday June 20th

Regional applications

Palaeodiet in Northern Eurasia: New Results from Stable Isotope Studies

Organized by: Yaroslav Kuzmin, Ricardo Fernandes and Svetlana Svyatko

This session is designed to present and discuss novel palaeodietary stable isotope and radiocarbon data from human and animal remains from the Central/Eastern Europe, Urals, Kazakhstan, Western Siberia, and the southern Russian Far East. The session will consider both marine and freshwater examples of radiocarbon reservoir effects and encourage researchers to engage in the interdisciplinary dialogue.

New radiocarbon datings and stable isotope analysis of human remains from the Neolithic Abora settlement, South-eastern Latvia

Dardega Legzdiņa[1], G Zariņa[1], IB Loze[2]

[1] University of Latvia, Institute of Latvian History, Riga, Latvia
[2] Latvian Academy of Sciences, Riga, Latvia

The Abora settlement is located at the Lake Lubāns wetland and is one of the well-known Stone Age sites in the region. So far, 27 Mesolithic and Neolithic sites have been identified throughout the wetland, making this region a significant Stone Age inhabitation complex not only in Latvian, but also in a wider North European context. Archaeological excavations have been conducted in 18 settlements, with Abora site being one of the most researched. Lake Lubāns wetland is located approximately 200 km from the Baltic Sea, making it an inland region.

Archaeological research and excavations in Abora started in the last century with several excavation seasons during the 60s and 70s. At the time, radiocarbon dating was already available for Latvian archaeologists, therefore several organic samples were dated during 70s and 80s. In 2008 research at the Abora settlement was renewed with excavations and new radiocarbon datings of organic samples.

However, until recently the human remains from burials found in the settlement have not been approached with bioarchaeological methods available nowadays. In this paper we present new radiocarbon datings of 6 individuals and carbon and nitrogen stable isotope analysis results of altogether 14 individuals, with the aim to discuss the burials in context of the settlement chronology, archaeological dating and possible offsets in radiocarbon dates made by freshwater reservoir effect.

Human diet variability in a long term perspective

Łukasz Pospieszny[1], J Giblin[2], K Kristiansen[3], K-G Sjögren[3]

[1] Institute of Archaeology and Ethnology, Polish Academy of Sciences, Poznań, Poland
[2] Quinnipiac University, Hamden, Connecticut, USA
[3] University of Gothenburg, Gothenburg, Sweden

In recent years there has been a significant increase of the number of isotopic studies aimed at reconstructing local food webs by applying $\delta^{13}C$ and $\delta^{15}N$ measurements of ancient human, animal and plant remains. Moreover, the isotopic analyses are now often conducted along with AMS radiocarbon dating. As a result large datasets of $\delta^{13}C$ and $\delta^{15}N$ signatures paired with 14C dates are becoming available. This allows for tracing changes in human diet over long periods of time with significantly high time resolution.

In this study we discuss the changes of human diets in Central Europe and Southern Scandinavia between the Early Mesolithic and the Middle Bronze Age. We used both published and newly received datasets from Denmark, Germany and Poland. We also applied Bayesian isotope mixing models to estimate to what extent the subsistence strategies in particular regions were based on terrestrial, freshwater and/or marine foods. Finally, we compared the consumption habits of individual people with their sex, age, form of burial and quality of grave goods. Our investigations lead to a number of conclusions. First of all, we found long term shifts in the isotopic composition of human bone collagen appearing simultaneously in all studied regions. Secondly, we concluded that changes in human diet in certain periods were caused by changes either in subsistence strategies or in social organisation. Last but not least, we noticed a high variability of $\delta^{13}C$ signals in fish skeletal remains from various locations in apparently similar postglacial landscapes.

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Palaeodietary patterns of the early iron age population in Primorye (Martime) Province, Russian Far East, based on stable isotope analysis

Yaroslav Kuzmin[1,2], V Panov[3], V Gasilin[4], S Batarshev[5], S Malkov[5]

[1] Sobolev Institute of Geology & Mineralogy, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russian Federation
[2] Laboratory of Mesozoic and Cenozoic Continental Ecosystems, Tomsk State University, Tomsk, Russian Federation
[3] Centre of Cenozoic Geochronology, Institute of Archaeology & Ethnography, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russian Federation
[4] Institute of Plant & Animal Ecology, Urals Branch of the Russian Academy of Sciences, Yekaterinburg, Russian Federation
[5] Scientific-Applied Centre of Historical-Cultural Expertise Ltd., Vladivostok, Russian Federation

Palaeodietary studies in the Russian Far East are still at the infancy stage (e.g. Kuzmin 2015). New results were obtained in 2015–2017 after discovery and excavation of the Cherepakha-13 site in Primorye Province. The site is located near the coast of Ussuri Bay, part of the larger Peter the Great Gulf, Sea of Japan (coordinates 43.28° N, 132.30° E), and belongs to the Yankovsky cultural complex of the Early Iron Age (Malkov 2017). Bones of several animal taxa were identified, both terrestrial and marine; the dominant species are red deer, Siberian roe deer, and wild boar. This site is very rich in human remains; in 26 burials, skeletons of 37 individuals were unearthed. Radiocarbon dating of associated charcoal shows the age of humans as ca. 3000 BP (ca. 1200–1300 cal BC). This is the largest prehistoric burial ground excavated so far with relatively well-preserved human osteological material in the entire region, encompassing the mainland Primorye and the Amur River basin, Sakhalin Island, and the Kurile Islands.

Stable isotope composition in the collagen of 11 humans and 30 animals was determined according to routine methods (e.g. Kuzmin 2015). As for humans, good quality collagen (C/N ratio of 3.0–3.4) yielded the following values (with ± 1 sigma): $\delta^{13}C$ = -10.2 ± 0.8 ‰; and $\delta^{15}N$ = +12.4 ± 0.3 ‰. Terrestrial animals (elk, red deer, roe deer, and wolf) show the usual isotopic signals, $\delta^{13}C$ = -19.4 – -23.3 ‰; and $\delta^{15}N$ = +4.6 – +6.6 ‰. Marine mammals (Steller sea lion and large seal) have common values for this kind of animal: $\delta^{13}C$ = -13.7 – -14.6 ‰; and $\delta^{15}N$ = +17.4 – +18.0 ‰. Dogs (six individuals) have an isotopic composition very similar to humans: $\delta^{13}C$ = -11.7 ± 1.2 ‰; and $\delta^{15}N$ = +12.4 ± 0.4 ‰.

According to these data, the main food resources for the population of Cherepakha-13 site were marine mammals, fish, molluscs, and C_4 plants (domesticated millets). The economy of the Yankovsky complex, according to zooarchaeological and archaeobotanical data, was based on a combination of hunting marine mammals, gathering marine shellfish, marine fishing, and to some extent terrestrial hunting and plant gathering, supplemented by millet and wheat agriculture (e.g., Kuzmin 1995, 1997; Kuzmin and Rakov 2011). Direct evidence from human bone collagen shows that marine organisms were the main protein sources for the people of the Yankovsky complex, following the earlier maritime-oriented Boisman cultural complex of the Neolithic, dated to ca. 5800 BP (ca. 4700 cal BC).

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Reconstructing the diet of Xiongnu individuals from the site of Burkhan Tolgoi (Mongolia)

Ricardo Fernandes[1,2], T Turbat[3], T Larsen[2], P Roberts[4], U Brosseder[5]

[1] University of Cambridge, Mcdonald Institute for Archaeological Research, Cambridge, UK
[2] Leibniz-Laboratory for Radiometric Dating and Isotope Research, University of Kiel, Kiel, Germany
[3] Institute of Archaeology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia
[4] Department of Archaeology, Max Planck Institute for the Science of Human History, Jena, Germany
[5] Pre and Early Historical Archaeology Department, University of Bonn, Bonn, Germany

An isotopic study was undertaken to investigate the subsistence strategies followed by humans buried at the Burkhan Tolgoi cemetery (Mongolia) dating between the end of the 3rd century BC and the 1st century AD, the time of the Xiongnu, who established the first steppe empire in Inner Asia.

We studied human and animal bone remains from Burkhan Tolgoi. Stable isotope ($\delta^{13}C$, $\delta^{15}N$) and radiocarbon measurements were made on extracted bone collagen, bone carbonate, and single amino acids isolated from bone collagen. Multi-proxy isotopic results were modelled using the Bayesian mixing model FRUITS to provide caloric dietary estimates.

Bayesian dietary estimates showed that the diets of Burkhan Tolgoi individuals were relatively homogenous. The main source of dietary protein was terrestrial animals but there were also significant contributions of freshwater fish. Bayesian estimates also showed that C_4 plants, likely including cultivated millet, were a major source of calories.

Investigating histories of individual shifts in diet and behavior in early neolithic hunter-gatherers from the Shamanka II cemetery on Lake Baikal, Siberia

Ian Scharlotta[1], G Goude[1], E Herrscher[1], A Weber[1,2], VI Bazaliiskii[3]

[1] Aix Marseille Univ, CNRS, Ministry of Culture & Commmerce, Aix-en-provence, France
[2] Department of Anthropology, University of Alberta, Edmonton, Alberta, Canada
[3] Department of Archaeology and Ethnography, Irkutsk State University, Irkutsk, Siberia, Russian Federation

Using a high-resolution chronological framework developed for Early Neolithic Cis-Baikal, Siberia, grave goods and stable isotope data are analyzed for specific relationships between functional items, prestige goods, and diet. Evidence suggests increasing importance of fishing during two separate phases of cemetery use at Shamanka II. Dietary changes and interlinked social structures may have contributed to differentiation in the cemetery. Fishing specialists are identifiable in grave assemblages. Individual fishers did not employ methods consistent with intensification. Their role in providing important food resources did not translate to apparent prestige or wealth in certain grave goods at Shamanka II.

Bulk data have indicated the presence of a mixed population in terms of origins and diet, the need for caution prior to their use in support of clear behavioral inferences, and further refinement of the methodological approaches. Dentine micro-sampling allows of sequential molars provides a detailed picture of the first 20 years of these individual's lives. With this insight, we can reexamine the grave good evidence in the context of detailed dietary information to identify both individual attributes and population trends through time linking diet and material culture.

Micro-sampling and early life dietary history among Early Bronze Age (~4600–3700 cal BP) hunter–gatherers on Lake Baikal, Siberia

Victoria van der Haas[1], O Goriunova[2],[3], Andrzej Weber[1],[4]

[1] University of Alberta, Department of Anthropology, Edmonton, Alberta, Canada
[2] Irkutsk State University, Department of Archaeology and Ethnography, Irkutsk, Russian Federation
[3] Institute of Archaeology and Ethnography, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russian Federation
[4] Aix-Marseille University, CNRS, Ministry of Culture & Commmerce, LAMPEA, Aix-en-Provence, France

This paper presents an investigation into the early life dietary history of Early Bronze Age (EBA) hunter-gatherers (~4600–3700 cal. BP) from the Cis-Baikal region, Siberia, using the method of micro-sampling dentine of permanent molars. The dentine has been sampled into 1mm slices each analyzed for carbon and nitrogen stable isotope ratios. As tooth dentine does not turnover once formed, each sample represents roughly nine months of developmental life. Micro-sampling allows for a more complete and informative record of early life dietary history with greatly improved temporal resolution of the geochemical signatures obtained. Previous geochemical tests on bone of the same individuals examined in this study demonstrated that during the EBA hunter–gatherer groups migrated from the north of the Cis-Baikal, the Upper Lena area, towards the coast of Lake Baikal, the Little Sea area. Some hunter-gatherers appear to have retained diets typical of their homeland while in other cases local diets appear to be relatively quickly adopted. Recent research also shows that the diet of these hunter-gatherers has influenced their radiocarbon ages due to a freshwater reservoir effect in Lake Baikal and its surrounding rivers.

Early Bronze Age (~4600–3700 cal BP) hunter–gatherer chronological and dietary patterns on Lake Baikal, Siberia

Andrzej Weber[1,2], R Schulting[3], CB Ramsey[3], OI Goriunova[4,5]

1 University of Alberta, Department of Anthropology, Edmonton, Alberta, Canada
2 Aix Marseille University, CNRS, Ministry of Culture & Commmerce, LAMPEA, Aix-en-Provence, France
3 University of Oxford, Research Laboratory for Archaeology and the History of Art, Oxford, UK
4 Irkutsk State University, Department of Archaeology and Ethnography, Irkutsk, Russian Federation
5 Institute of Archaeology and Ethnography, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russian Federation

Over the last 20 years, the Baikal Archaeology Project has invested many resources into research on Middle Holocene (~8300–3500 cal BP) hunter–gatherers of the Cis-Baikal region in Siberia. Examination of new materials excavated by the project and analysis of previously accumulated archaeological collections produced many new insights on just about every aspect of Baikal's hunter–gatherers. We now have a very good record of spatial and temporal variation in diet, subsistence, mobility and migrations, health, trauma and activity patterns, population size and distribution, mortuary practices and some information on genetic structure. A recent breakthrough is the identification of the Freshwater Reservoir Effect (FRE) in the regions ecosystem and the development of a method that allows radiocarbon dates done on human skeletal remains to be corrected for it. This, in turn, facilitates two studies that previously could not be undertaken: (1) building chronologies of decadal resolution for the Baikal region at different spatial scales from an individual cemetery through to the entire region; and (2) tracking dietary changes over time with equal spatio-temporal resolution. The paper focuses on Early Bronze Age (~4600–3700 cal BP) hunter–gatherers in the Little Sea area on Lake Baikal and identifies a few entirely new chronological and dietary patterns among these groups.

Group photo

~~Diet and economy of the Neolithic to early Iron Age populations from the South of Western Siberia [CANCELLED]~~

Svetlana Svyatko[1], P Reimer[1], D Papin[2], M Rykun[3], O Posheknonova[4]

1 [14]CHRONO Centre for Climate, the Environment, and Chronology; Queen's University Belfast, Belfast, UK
2 Laboratory of Interdisciplinary Study of Archaeology of Western Siberia and Altai, Altai State University, Barnaul, Russian Federation
3 Cabinet of Anthropology, Tomsk State University, Tomsk, Russian Federation
4 Institute of Problems of Development of the North, Siberian Branch of the Russian Academy of Sciences, Tyumen, Russian Federation

We present our recent investigations into the economy and lifestyle of the Neolithic to Early Iron Age populations from Western Siberia (30 sites, 140 human and faunal individuals in total). The samples derive from two major areas – Ob River and Tobol-Irtysh Interfluve.

For modern archaeological research, stable isotope techniques are an important part of the interpretation of the artefactual informaiton, however, these analyses are still only emerging for many areas. Such territories include the south of Western Siberia, where only recently stable isotope data started to be utilised. The region represents one of the areas, where, since the Neolithic, the society of hunters and fishers were formed. In its northern taiga zone, they continued to exist until modern times, while in the southern steppe and forest-steppe areas, the economic focus shifted towards pastoralism in the Bronze Age, and it further fully developed in the Early Iron Age. These economic reconstructions are primarily based on the analysis of the osteological faunal assemblages and interpretation of tools. The latest isotopic data allow new insights into the evolution of the subsistence of the prehistoric societies in the south of Western Siberia.

The results of carbon and nitrogen isotope analysis and AMS radiocarbon dating of the individuals demonstrate that:

- the diet of all populations analyzed likely included fish, however, its proportion gradually decreased towards the Early Iron Age;
- the diet of all Neolithic-Bronze Age populations was predominately C_3-based, but the results of at least four individuals from three sites in Ob River region suggest consumption of C_4 sources from the 14th-13th c. cal BC. The $\delta^{15}N$ values of these particular individuals are relatively low (in fact, some of the lowest among the analysed humans) and do not indicate the presence of fish in their diet;

- in the Early Iron Age, the diet of the Ob River region population became much more diverse (mainly between groups, rather than within), and in many cases included large proportions of a C_4 component. The economy of the Tobol-Irtysh Interfluve population, however, did not appear to include any C_4 resources in the Early Iron Age;
- the appearance of C_4 signal in the Ob River region samples likely indicates the introduction of millet cultivation to the region by the Irmen Culture population from the 14th c. BC, and more systematic use of millet in the area from approximately the 5th c. BC.

The comparison of the results for the south of Western Siberia with data from previous research demonstrates clear transition patterns, from foraging in the Neolithic time to introduction of pastoralism in the Early Bronze Age, and to integrating of cereal cultivation in the Early Iron Age. The data also clearly shows non-uniformity of the economic patterns between various Bronze and Early Iron Age groups, when some populations continued their reliance on wild resources and did not employ cereal cultivation even at the later periods.

Further research into freshwater reservoir effects in the region is essential for verifying the date of the introduction of millet into the area, as well as generally the chronology of the sites.

Dietary patterns in Medieval Russian cities, based on radio-isotope analysis of the ($\delta^{13}C$/$\delta^{15}N$) collagen content of human bone remains. New data from Moscow, Yaroslavl, Tver', Dmitrov, Smolensk, Mozhaisk, other locations)

Asya Engovatova

Institute of Archaeology Russian Academy of Sciences, Moscow, Russian Federation

The last 8 years have produced a sample-base of isotope analyses of human bone material from burials of the 12th-17th centuries. This enables reliable illustration of the diet in forested zones of Medieval European Russia.

Isotope analysis of $\delta^{13}C$ and $\delta^{15}N$ levels used standard mass-spectrometry measurement methods (Arslanov method) – releasing collagen, measuring the content of these isotopes.

The objectives of this research were:

1. Establishing dietary patterns of Medieval urban populations (and comparison with countryside populations, and monastic burials)
2. Comparing diets of men, women, and children
3. Examining dietary patterns typifying social stratification (comparing diets among urban Kremlin dwellers with poorer suburbs)
4. Examining urban dietary differences at different periods (12th to 17th c).

Currently, delta isotope values are available for carbon and nitrogen isotopes from human collagen from:

1. Urban burials: Yaroslavl (13th and 16th-17th centuries) - 86 and 22 samples; Tver' (12th-17th centuries) – 84; Smolensk (12th, 15th, and 16th centuries) – 26; Dmitrov (12th-13th, 15th-16th , 16th-17th centuries) – 30; Pereslavl-Zaleski (up to the 15th-16th centuries) – 30; the Moscow Kremlin (turn of the 14th/15th & 17th centuries) – 57; Kolomna – 18; Mozhaisk (15th c) – 29; Bolgar (latter 16th c) – 17; Monastic cemeteries: the Trinity St Sergius Lavra (latter 15th-17th c), 25;
2. Burial sites of rural communities: 12th-13th c: Novoselki, 7; Rastorguevo – 3.

The benchmark group (and first to be analysed) for analysis and comparison are the mass grave burials from Yaroslavl in 1238. Unexpected results were high protein levels (meat) consumed by Yaroslavl's 13th-century population. Despite a Volga riverside location, levels of freshwater fish consumption in results were significantly lower. Male/female diets did not differ: no gender-based differences appear in the results. Child diets in Yaroslavl are of interest. The $\delta^{15}N$ levels for 2-3 year olds are somewhat higher than for adults.

The Yaroslavl results were compared with other Medieval urban populations. Similarities were noted with diets of other social groups whose remains were unearthed at high-status burial sites located in city centres of Medieval Russian cities (primarily at Kremlins) such as Tver or Dmitrov. The diets of those buried in city suburban locations (at Mozhaisk or Smolensk) displayed lower protein consumption.

Analysis of once-rural burial locations which are today in the Greater Moscow area (settle-

ments of Novoselki or Rastorguevo) shows the median arithmetic values for nitrogen delta for earthworks burials are lower – indicating a greater plant-based component in daily meals. In the pre-Mongolian era (prior to the 1230s) the diet of rural populations was relatively stable and uniform.

A high level of dietary protein is found among those buried at the Trinity St Sergius Lavra monastery cemetery.

Archaeological investigations were made in the Moscow Kremlin in 2016, which was the Russian capital from the 15th to 17th centuries. Isotope analysis results for burials in the Moscow Kremlin (including monastic burials) in this period show the highest protein intake levels among all groups studied.

There is a confirmed influence of social factors in establishing dietary patterns for Russian Medieval urban populations over the 12th to 17th centuries. Members of the classes of society deemed as 'privileged' at that time ate a high-protein diet (high in meat and dairy products). The dietary norms of other social groups (in rural locations) was clearly far more plant-based. Over the 12th-13th centuries, social factors played the determining role in the kind of dietary model available to people at that time.

These are the first studies of their kind to be made in Russian archaeology. Research and analysis are still ongoing.

Refining the radiocarbon chronology of Yuzhnyi Olenii Ostrov, Karelia, NW Russia

Rick Schulting[1], T Higham[1], C Bronk Ramsey[1], V Khartanovich[2], V Moiseyev[2], D Gerasimov[2], K Mannermaa[3], P Tarasov[4], A Weber[5]

[1] School of Archaeology, University of Oxford, Oxford, UK
[2] Peter the Great Museum of Anthropology and Ethnography (Kunstkamera), St Petersburg, Russian Federation
[3] Department of Philosophy, History, Culture and Art Studies, University of Helsinki, Helsinki, Finland
[4] Institute of Geological Sciences, Freie Universitaet Berlin, Berlin, Germany
[5] Department of Anthropology, University of Alberta, Edmonton, Alberta, Canada

With over 170 extant burials, Yuzhnyi Olenii Ostrov is one of the largest Stone Age cemeteries in northern Eurasia. It has long featured in debates concerning the emergence of social complexity and inequality. A missing component in these discussions has been a robust and precise absolute chronology. While a number of radiocarbon determinations are available, confirming the cemetery's attribution to the Mesolithic period, these suffer from a number of problems in terms of precision. Moreover, there is the potential for significant freshwater reservoir effects (FRE) that have not been taken into account. Here, we investigate the extent of the FRE through a programme of paired dating of human and terrestrial animal bone from the same graves. The results fall into two groups, one with a significant FRE of up to 330 14C years, while another group shows no significant 14C offset. Unexpectedly, the two groups have similar stable carbon isotope values, and equally high stable nitrogen isotope values. Possible explanations for this finding are discussed.

How fishy was the inland Mesolithic? New data from Friesack, Brandenburg, Northern Germany

Harald Lübke[1], B Gramsch[2], D Groß[1], C Hegge[3], J Meadows[1,4], HK Robson[1,5], T Terberger[6]

[1] Centre for Baltic and Scandinavian Archaeology (ZBSA), Schleswig, Germany
[2] Retired; Formerly Brandenburg State Office for Preservation of Monuments and State Archaeological Museum, Potsdam, Germany
[3] Institute for Natural Resource Conservation, Kiel University, Kiel, Germany
[4] Leibniz-Laboratory for Radiometric Dating and Stable Isotope Research, Kiel University, Kiel, Germany
[5] BioArCh, University of York, York, UK
[6] Lower Saxony State Office for Cultural Heritage, Hannover, Germany

Since the beginning of this millennium, palaeodietary studies of Northern European hunter-gatherer-fisher populations using stable isotope analyses have become more and more popular. One application of individual diet reconstruction is the detection and quantification of dietary radiocarbon reservoir effects, which are correlated with the importance of aquatic products as foodstuffs, an important research question in itself. Even at a societal level, the archaeological record does not resolve this question, as the function of simple and barbed bone points, in particular, as hunting weapons or fishing equipment has long been debated. Recent investigations, however, have shown that archaeozoological assemblages from early Mesolithic sites contain more fish remains than previously suspected.

Here we present new archaeozoological and stable isotopic data for a range of herbivores (auroch, elk, red and roe deer, beaver) and freshwater fish (northern pike, European perch, European eel and Wels catfish) species, together with radiocarbon and stable isotope data from eight prehistoric humans, from the renowned Early Mesolithic to Early Neolithic site of Friesack IV. The availability of local reference data for herbivores and fish allows the amount of fish consumed by each individual to be quantified. Using modern values for local freshwater reservoir effects, we can then calibrate the human radiocarbon ages.

Although the number of human samples is small, it is possible to infer a decline in the dietary importance of fish from the Preboreal to the Boreal Mesolithic, and an increase in aquatic resource consumption from the Early Neolithic onwards. Finally, we will compare these data with comparable prehistoric sites in Northern Germany, including Groß Fredenwalde and Ostorf-Tannenwerder.

~~Radiocarbon chronology and some aspects of the palaeodiet of the Altai populations during the Great Migration Period (2nd – 5th c. AD) [CANCELLED]~~

Svetlana Svyatko[1], A Tishkin[2], N Seregin[2], V Soenov[3], P Reimer[1]

[1] [14]CHRONO Centre for Climate, the Environment, and Chronology; Queen's University Belfast, Belfast, UK
[2] Laboratory of Interdisciplinary Study of Archaeology of Western Siberia and Altai, Altai State University, Barnaul, Russian Federation
[3] Research Centre for the History and Culture of the Turkic Peoples, Gorno-Altaisk State University, Gorno-Altaisk, Russian Federation

The Great Migration Period is one of the most important periods in Eurasian history, which defined the fate of many populations. Investigation of the processes that took place in the first half of the 1st mil. AD in various parts of Central Asia is mainly based on the analysis of archaeological sites. To date, the most representative materials for the period have been obtained from the Altai sites. One of the major issues in the study of these sites is the ambiguity of their current chronology, which hinders any historical reconstructions in the region. Until now, the chronology of the 2nd-5th c. AD burial complexes of Altai has been based on the analysis of the material complex. Considering the potential of modern techniques, there is an obvious necessity for refinement of traditional archaeological dating by radiocarbon (^{14}C) analysis. Furthermore, virtually no data is available on the nature of life-sustaining systems or economies of the Altai nomads during the Great Migration Period.

The main objectives of this research are the establishment of the ^{14}C chronology for the sites, identifying the possible impact of the freshwater reservoir effects (FREs) on human bone samples, and generating new data on subsistence of the populations. Materials from four major necropolises of the Great Migration Period in Altai, including Kuraika, Stepushka-I-II, Verkh-Uimon and Jaloman-II, have been used.

Archaeological analysis of the sites suggests the existence of two phases in the development of the Bulan-Koba archaeological culture, conditionally labelled as "Belo-Bombskiy" (2nd - first half of the 4th c. AD) and "Verkh-Uimonskiy" (second half of the 4th - first half of the 5th c. AD). The ^{14}C results (36 samples of human and domestic herbivore bone, wood and leather) from several laboratories confirm these findings. The defined phases correspond to the periods of influence of the two Central Asian nomadic empires – Xianbei Empire and Rouran Kaganate – on the Altai population, which, obviously, defined the dynamics of the material culture of nomads on the periphery of these political bodies.

FREs are a source of dating uncertainty for individuals whose diet includes non-atmospheric based carbon. Since this study included ^{14}C dating of humans, it is essential to assess the extent of the FRE in the area. Previous research demonstrated freshwater reservoir offsets of 578±36 and 1097±40 ^{14}C years in modern fish from local rivers. Our current paired samples of associated human and terrestrial herbivore bones, however, are somewhat inconclusive regarding the presence of FRE, with one pair showing no offset, two pairs showing older ages of herbivores, and one pair showing an older age of human sample. The presence of the effect could not be confirmed from the earlier study of the Afanasyevo samples in the region either, as the single associated human-herbivore pair analysed did not show a statistical difference. A similar situation has been observed for the Minusinsk Basin, with modern fish having strong reservoir offsets whereas archaeological humans are identical in ^{14}C age or younger than associated

herbivores. Further research with additional associated paired material is essential for understanding the influence of FRE on archaeological human samples.

The detection of the FRE on human samples is hampered by the fact that it is not clear whether humans consumed any significant amount of fish. Stable isotope data for eight samples from Kuraika and Verkh-Uimon indicate strong climatic influence on both human and faunal carbon and nitrogen isotopes, heavy reliance of humans on domestic herbivores, and the lack of C_4 signal in the area until the first half of the 1st mil. AD. Generally, C_4 plants (millets) are known to be a part of the diet of Southern Siberian populations from at least 14th c. BC, however, the environmental specifics of the areas where Kuraika and Verkh-Uimon are located would not allow development of cereal cultivation.

SESSION 1A, Thursday June 22nd

Methodological advances

Compound specific radiocarbon determination

Organized by: Sven Isaksson

This session focus on the recent developments in the field of compound specific radiocarbon analysis (CSRA) as a tool to chronologically dissect chemically complex biomolecular residues found in matrices related to human dietary behaviour. These matrices can consist of anthropogenic soils, sediments, as well as finds of bones and potsherds from archaeological contexts. Many of these residues are often complex mixtures of biological material and the direct radiocarbon dating of which are far from unproblematic.

Detection of human dietary radiocarbon reservoir effects through the radiocarbon dating of single amino acids

Ricardo Fernandes[1,2], T Larsen[2], C Hamann[2]

[1] University of Cambridge, Mcdonald Institute for Archaeological Research, Cambridge, UK
[2] Leibniz-Laboratory for Radiometric Dating and Isotope Research, University of Kiel. Kiel, Germany

Aquatic food sources often have radiocarbon values lower than the synchronous atmospheric value, an effect known as a radiocarbon reservoir effect (RRE). Thus, humans or animals consuming aquatic foods may exhibit a dietary RRE. For example, archaeological studies of different historical periods have demonstrated that human bone collagen samples can date hundreds of years older than the known time of death. For human remains with unknown time of death, it is often challenging determining whether the radiocarbon age is influenced by diet or not.

A promising approach to detect human RREs is the radiocarbon dating of single amino acids isolated from extracted bone collagen. This approach requires 1) a method for the isolation and radiocarbon dating of single amino acids with a measurement uncertainty comparable to that of standard bulk collagen measurements; 2) characterization of carbon routing mechanisms from food nutrients to consumer amino acids using isotopic data from controlled animal feeding experiments; 3) testing the developed methodology on bone remains from humans with a wide diversity in dietary choices.

The items above will be discussed and novel research results presented.

SESSION 1B, Thursday June 22nd

Methodological advances

Compound-specific stable isotope analysis for palaeodietary reconstruction

Organized by: Richard Evershed

In this session, we encourage presentations on compound specific isotope analysis of materials such as bones and food remains. Different compounds can have different isotope ratios, which can be helpful in palaeodietary reconstruction. Contributions on methodological aspects, experiments and innovations as well as interpretive considerations are very welcome.

Diet of Tollund Man. Stable isotope analyses of an Iron Age bog body from Denmark

Nina Helt Nielsen[1], B Philippsen[2],[3], LV Jensen[1], M Kanstrup[2], J Olsen[2]

[1] Silkeborg Museum, Silkeborg, Denmark
[2] Aarhus AMS Centre, Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark
[3] AU STAR Network (Science and Technology in Archaeological Research), Department of Archaeology, Aarhus University, Aarhus, Denmark

Tollund Man is one of the world's most famous bog bodies due to his exceptionally well-preserved head. He was found in 1950 by peat cutters in a bog near Bjældskovdal, c. 10 km west of Silkeborg. During the years, several analyses have been performed on the body to shed light on the life and death of Tollund Man. The investigations have primarily included forensic and medical examinations, X-rays, CT-scans and microscopical analyses of e.g. the stomach content, while chemical and isotope analyses have not been conducted.

In 2016, an extraordinary grant from the municipality of Silkeborg enabled Museum Silkeborg to initiate a range of new scientific investigations of Tollund Man and the associated finds. These include protein analysis, multi-element analysis, Sr isotope analysis and analysis of the stable isotopes of N, C and S.

This presentation focuses on measurements of the stable isotopes in bone and hair of Tollund Man. The analysis of the isotopes of C, N and S reveals the diet on long and short time scales: The isotope signature in the bone sample reflects the average diet in the years prior to death; the isotope signature in the hair reflects the diet in the last months of his life. Any difference between the results of the two analyses may indicate a change in the diet in the months before death and could potentially shed light on the circumstances leading to the human sacrifice of Tollund Man.

After excavation, the femur bone (and the main part of the body) of Tollund Man was merely left to dry out, and the bone sample could therefore be analysed without special pretreatment. The hair, on the other hand, had been treated with wax, which needed to be removed prior to analysis. The successful method of pre-treatment will be presented.

Isotopic compositions as cultural markers? A study on ancient Crimea

Jens Andresen[1], E Bartelink[2], S Lantsov[3], M Mannino[1], I Nechaeyev[2], V Stolba[1]

[1] Aarhus University, Department of Archaeology and Heritages Studies, Højbjerg, Denmark
[2] California State University, Chico, California, USA
[3] Institute of Archaeology of the Crimea, Russian Academy of Sciences, Simferopol, Crimea, Russian Federation

Located at the crossroads of major trading routes, Crimea has experienced pronounced cultural diversity throughout her turbulent history. Archaeological finds from the peninsula, such as Egyptian scarabs of lapis lazuli, Chinese lacquer boxes, Gothic fibulae, Scythian and Sarmatian gold, as well as Greek fin ware and coins are just a few, yet spectacular expressions of Crimea's rich and diverse past and links to the outer world.

In this study we will focus on NW Crimea in the last four centuries BC and the first centuries AD. At the beginning of this period, the area formed part of the chora (rural territory) of the Greek colonial city state of Chersonesos. At the end, the Late Scythian Culture had taken control.

NW Crimea itself forms part of the Pontic-Caspian steppe region with very little yearly rainfall (<400 mm p.a.) and a bedrock of karst limestone. The fertile Calcic Chernozems (loess-like loams) form large plains in the center of Tarkhankut, which was cultivated inland in the Greek period and, probably, after. Greek settlements were located along the coast, and, in the 2nd century BC, were replaced by the Scythians.

In 2007 a new type of habitation from the forth through the early third century BC was discovered. Well preserved, these structures were clearly discernable on the surface as stone scatters or protruding foundations of the walls. The first of them to be excavated – House 1 at Kelsheikh – surprised in many ways. One of the big discoveries was a number (4-5) of human skeletons. They seem to be contemporary with violent attacks on the Greek coastal habitations, from which human skeletal material is preserved as well.

Since diet is a product of cultural habits, remains of about 27 individuals from different coastal and inland sites, dating to Greek occupation and after, were sampled for isotopic investigation of dietary difference and similarity. The isotopic baseline for this study is provided by bone samples of ancient terrestrial herbivores recovered from cooking pots, kitchens, and refuse layers, in addition to modern material.

California State University, Chico prepared all samples for stable isotope analysis. Stable carbon and nitrogen isotope of bone collagen data are available, which largely reflect the protein contributions to the diet. In general, the $\delta^{13}C$ and $\delta^{15}N$ values are similar and largely reflect consumption of C_3 resources, and also suggest broadly similar diets between the different cultures. However, slightly higher $\delta^{13}C$ values at Mar'inskoe suggest either some consumption of C_4 plants or some input from marine resources at this site. Data on the $\delta^{13}C$ of bioapatite is forthcoming and should provide additional information on the non-protein sources of the diet, including whether C_4 or marine resources were consumed at Mar'inskoe.

SESSION 1C, Thursday June 22nd

Methodological advances

Human and animal diet reconstruction using numerical methods

Organized by: Ricardo Fernandes, Andrew Millard

Estimating human palaeodiets based is complex and often involves numerous food groups. Here we welcome presentations using numerical models to estimate dietary food groups.

Statistical comparison of incremental isotope profiles using SITAR

Andrew Millard[1], E Kendall[1], T Cole[2], J Beaumont[3]

[1] Durham University, Department of Archaeology, Durham, UK
[2] University College London, London, UK
[3] University of Bradford, Bradford, UK

Incremental isotope analysis of dentine increments is rapidly becoming an established method to examine changes in childhood diet and metabolism. Human tooth dentine forms from the foetal period through to 20 or more years of age, opening up the possibility of examining changes across the whole of the growth and development period using $\delta^{13}C$ and $\delta^{15}N$. This has enabled detection of short-term dietary changes, such as an increase in marine food consumption, comparison of weaning between survivors and non-survivors, and the identification of periods of metabolic stress leading to catabolism.

However, the method is not without difficulties. For practical reasons dentine is usually sampled perpendicularly to the growth axis of the tooth. However, the actual growth is more paraboloid in shape, so one increment produces time averaging beyond what is predicted from a simple linear growth model. Teeth from different individuals have different completed lengths, so a fixed slice thickness leads to variation in time averaging between individuals. Previous work has tended to plot isotope results using the mid-point of an estimated formation age-range, and then to make visual comparisons between the curves for different individuals.

Here we present a novel method for comparing and classifying incremental isotope profiles. We draw on the strong statistical tradition in the analysis of human growth curves which has led to the development of a curve comparison method called Super-Imposition by Translation And Rotation (SITAR). SITAR is robust to differing measurement ages for different individuals, thus compensating for mid-point ages for increments that vary between individuals. For each incremental profile, a spline curve is fitted to the data. SITAR then takes this series of curves and matches them to a mean curve for the dataset by applying three transformations: (i) shifting vertically, representing a change in mean isotope value between individuals, (ii) shifting horizontally, representing differences in the timing of events, and (iii) stretching or shrinking the age scale, representing differing rates of isotopic change, or of dentine growth, between individuals. This results in computation of a mean curve and a trio of parameters for each individual that summarise how their incremental isotope profile differs from the mean.

We have applied this method to a set of incremental isotope profiles obtained from the early Medieval sites of Littleport and Edix Hill in Cambridgeshire, UK. The model works extremely well for δ15N profiles, explaining about 90% of the variance in the data. The explanatory power is less for $\delta^{13}C$ profiles, probably because here the measurement error is a much larger proportion of the variance in the data, and thus the profiles are relatively noisier than for $\delta^{15}N$. In each case the summary statistics from the model allow us to explore whether there are groups of individuals with curves that are similar in each or all of the parameters modelled. The mean curves allow us to make a population-level interpretation of underlying trends in $\delta^{13}C$ and $\delta^{15}N$ values. Here we see that the underlying trend for $\delta^{15}N$ is a decline of about 3 ‰ from birth to a constant value after about 2 years of age. This is consistent with the expected change in $\delta^{15}N$ due to weaning, but is not easily visible in the individual profiles. The time-

averaging of the initial increment and the smoothing in fitting a spline curve probably conceal any initial rise in $\delta^{15}N$, although this is predicted by models of weaning. For $\delta^{13}C$, the trend is a decrease of about 0.5 ‰ from birth to about 2 years as might be expected with weaning, but then a rise of 0.75 ‰ for which there is no clear explanation.

Isotopic reconstruction of diet and mobility of the archaeological populations from coastal Taltal, Northern Chile (~6800-300 cal BP)

Pedro Andrade[1], R Fernandes[2],[3], K Jaouen[4], P Roberts[5], J Urrea-Navarrete[1], D Salazar[6], C Hamann[7], C Flores[8], L Olguin[9]

[1] School of Anthropology, Universidad de Concepcion, Concepcion, Chile
[2] McDonald Institute for Archaeological Research, University of Camdridge, Cambridge, UK
[3] Leibniz-Laboratory for Radiometric Dating and Isotope Research, University of Kiel, Kiel, Germany
[4] Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany
[5] Department of Archaeology, Max Planck Institute for the Science of Human History, Jena, Germany
[6] Department of Anthropology, Universidad de Chile, Santiago, Chile
[7] Leibniz-Laboratory for Radiometric Dating and Isotope Research, Kiel University, Kiel, Germany
[8] Center for Climate and Resilience Research, La Serena, Chile
[9] PhD in Anthropology Programm, Universidad Católica del Norte, Santiago, Chile

The interfluvic coast of the Atacama Desert is one of the most hostile environments in the world as a result of hyper-aridity due a stark absence of permanent watercourses, leading to a very low agricultural productivity. Furthermore, the region is prone to the occurrence of natural catastrophes, such as earthquakes, tsunamis and extreme climatic conditions caused by ENSO events, among others, that had a significant impact on local populations. Despite such harsh conditions, the area maintained a relatively stable human occupation throughout the Holocene. This wide time interval witnessed important changes in paleoenvironmental and paleoceanographic conditions. The technology employed by past populations and their settlement patterns also varied considerably.

Ancient Taltal inhabitants were characterized by a lifestyle based on hunting and gathering, which was maintained until and even after the arrival of Europeans. Despite the social and cultural transformations that occurred to the north and south of the area and in the hinterlands, and the contact with the populations from those areas, there was no profound effect on the way Taltal groups exploited available wild resources (e.g. a late and scarce local ceramic and metallurgic production, and null development of agricultural techniques). In view of the archaeological evidence, $\delta^{15}N$coll, $\delta^{13}C$coll, $\delta^{13}C$bioap, $\delta^{18}O$bioap and 87Sr/86Sr isotope data were obtained to investigate the subsistence strategies and mobility patterns of past Taltal populations.

A local isotopic environmental baseline was defined from the isotopic analysis of human-exploited animal species present in the archaeological record. Through Bayesian modelling of consumer and baseline isotopic values estimates of individual dietary intakes were generated. Model estimates and mobility isotopic proxies show that despite contacts with agropastoral populations from the hinterlands, and changes in coastal environmental conditions, Taltal populations were essentially local and had a constant dependence on marine food resources. As a consequence of the above, a review of the radiocarbon-based chronology established for the individuals from Taltal is proposed taking into account dietary radiocarbon reservoir effects.

Exploring diet in Medieval Thebes (Greece), through a multi-stable isotope approach

Dimitra Ermioni Michael, E Dotsika

Institute of Nanoscience and Nanotechnology, National Center For Scientific Research, "Demokritos", Aghia Paraskevi, Attiki, Greece

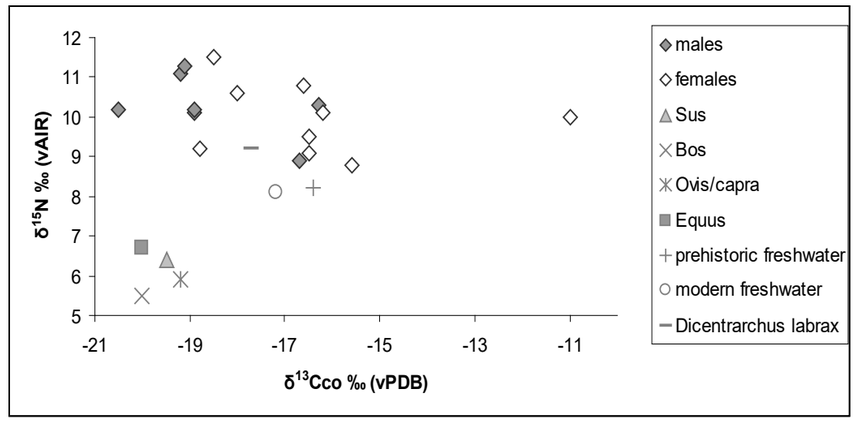
Diet is an integral component of the cultural heritage of ancient populations. In particular, identifying possible dietary differences between sub-groups within a population; such as between people with different socio-economic status; between the two sexes; or between individuals of different age, can reveal important social differentiations between them. The dietary reconstruction of a past population can be approached through the literary sources, dental pathology, faunal and plant remains, remains in storage vessels and food preparation utensils. However, none of the above sources could provide us with secure information, as to what food items were actually consumed. Thus, stable isotope fingerprinting on human remains is considered an extremely important technique in bioarchaeology, for its ability to determine food sources that were eaten and identify their relative quantities in the diet.

Hence, the present study aims to explore the dietary habits of a medieval population from Thebes (13th-14th centuries A.D.), to explore possible dietary differentiations in relation to sex and age and to detect possible differences between the adult and the childhood/juvenile diet. For the needs of the aforementioned goals carbon isotope in bone collagen, bone apatite and tooth enamel; as well as nitrogen isotope in bone collagen have been analyzed. The skeletal collection of Thebes consists of 16 adult individuals, 7 male and 9 female. 16 bone samples and 11 tooth samples were isotopically analyzed at the Stable Isotope and Radiocarbon Unit of N.C.S.R. 'Demokritos'.

Collagen isotopic values tend to represent the protein component of the diet. The mean δ^{13}Cco for the 16 bone samples is -17.3 ± 2.2 ‰, whereas δ15N is at 10.1 ± 0.8‰. A typical C_3 terrestrial diet is thought to present carbon values more negative than -19‰ and nitrogen values below 10‰. Interestingly the population under study presents a quite diverse pattern. Six human samples indicate a more terrestrial based diet, whereas nine human samples a more marine/freshwater dietary preference. The case of Th22 (female; 20-35 years old) is a unique case (δ^{13}Cco -11‰; δ^{15}N 10‰). The carbon collagen isotopic difference between the two subgroups (terrestrial versus marine/freshwater consumption) is statistically significant (p=0.00), contrary to nitrogen isotope values where no such differentiation is noted. Apatite mean value at -9.9 ± 2.5 ‰ (total diet indicator), also reflects a non-typical C_3 terrestrial diet. In contrast the carbon collagen-apatite spacing (Δ13Cap-coll) at 7.1 ± 2.4‰ indicates a mixed diet balanced between terrestrial and marine/freshwater food items, as Δ13Cap-coll is related to trophic level. Moreover, the carbon enamel analysis also indicates a non-typical C_3 terrestrial diet [N=11 samples; mean δ^{13}Cen : -7.7 ± 2.5‰]. Enamel isotopic signal reflects the childhood/juvenile diet, due to the fact that tooth enamel is formed during only a limited part of an organism's life, and thus the isotopic signature captured is that of the diet during the period of enamel formation.

The enriched carbon collagen values could also be attributed to a significant C_4 food consumption, like millet. However, based on the information regarding the geographical location of Thebes (access to both marine and freshwater sources) along with the literary sources, it seems that at least for a significant percentage of this population marine/freshwater food items constituted a major portion of their diet. The isotopic variability among the 16 individuals under study could be related to an ethnological/cultural diversity.

The isotopic results will be further discussed at the upcoming conference in relation to literary sources, climatic conditions, migratory behaviour, ancient and modern isotopic reference database (plants and faunal remains), as well as previous dental results.



New developments in reconstructing subsistence using FRUITS

Ricardo Fernandes[1,2], A Millard[3], C Bronk Ramsey[4], M Brabec[5]

[1] University of Cambridge, Mcdonald Institute for Archaeological Research, Cambridge, UK
[2] Leibniz-Laboratory for Radiometric Dating and Isotope Research, University of Kiel, Kiel, Germany
[3] Department of Archaeology, Durham University, Durham, UK
[4] ORAU, University of Oxford, Oxford, UK
[5] Institute of Computer Science, The Czech Academy of Sciences, Prague, Czech Republic

FRUITS (Food Reconstruction Using Isotopic Transferred Signals) is a user-friendly software that offers users the possibility of implementing Bayesian model instances to address a wide variety of mixing problems. As new isotopic data emerges and FRUITS is applied to a wider range of problems it becomes necessary to update the software so that it adequately addresses new research challenges.

Recent results from feeding experiments have demonstrated the complexity of reconstructing ancient human diets from isotopic data. Aspects such as individual physiological variability, dietary quality, and nutrient routing mechanisms must be incorporated into the modelling process. Within radiocarbon studies the quantification of the dietary contributions from aquatic food sources is key to correct for dietary radiocarbon reservoir effects and obtaining reliable chronologies. Dietary estimates may remain relatively imprecise and novel forms of improving the precision of dietary estimates through the inclusion of archaeological and physiological evidence should be explored. Furthermore, given that model outputs for aquatic intakes may differ from common distribution probabilities it becomes necessary to feed directly calibration programmes (e.g., OxCal) with the raw model outputs. A novel application of FRUITS is the reconstruction of pottery use from fatty acid carbon isotope signatures. Carbon isotope measurements of individual fatty acids (C16:0 and C18:0) recovered from archaeological pottery vessels are widely used in archaeology to investigate past culinary and economic practices. Fatty acid carbon isotope values within lipid groups are highly correlated, so modelling this type of mixture within FRUITS requires the addition of the ability to represent food sources with multivariate normal distributions.

This paper will discuss the development of interfaces to radiocarbon software, application of FRUITS to compound-specific $\delta^{13}C$ data, and other novel aspects.

Using dietary reservoir effects to correct calibrated radiocarbon ages: analysing a high medieval multiple grave from Odense, Denmark

Helene Agerskov Rose[1], J Meadows[1], MM Bjerregaard[2]

[1] ZBSA, Stiftung Schleswig-Holsteinische Landesmuseen, Schleswig, Germany
[2] Odense City Museums, Odense, Denmark

We present new radiocarbon and stable isotope results from a multiple grave from the High Medieval St. Alban cemetery in Odense, containing five contemporaneous individuals between the ages seven and eighteen.

The site has a complicated history involving several church buildings; first built in wood in the early medieval period and later in the 11th century set in stone. Odense City Museums has directed excavation campaigns in different sections of the cemetery, most recently in 2015-16 (OBM3183, OBM9776/2), where among some 400 burials from c. AD 1100-1350, the multiple grave discussed here was found.

Multiple burial is a rare but not unknown phenomenon in the medieval period in Scandinavia, but its interpretation is debatable. Five individuals were interred in grave A156; two sub-adults aged 7-9 years-at-death and three older sub-adults aged respectively 13-16 and 14-17 and 15-18 years-at-death. It was not possible to determine the sex with certainty of any individual. The five sub-adults were interred in the same grave in two layers and are archaeologically interpreted as having died within a short period of time. Given the demographic profile of this specific grave and the lack of any distinctive skeletal pathology, we propose the five individuals in question died because they had contracted an unknown re-occurring viral disease that the surviving older individuals in the society had developed immunity against. Being buried together would then primarily serve a practical purpose.

We sampled dentine from the crown of a permanent first molar from each of the five individuals for AMS dating and stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$, $\delta^{34}S$), thereby targeting the formation period 1.5-4 years-of-age. Thus, given the age-at-death estimates, the radiocarbon events embodied in these samples (the formation of dentine in each tooth) took place between 5±1.2 and 13.5±1.3 years before the date of the multiple burial.

We use OxCal to create a Bayesian chronological model incorporating these constraints. To the extent that the calibrated radiocarbon results are incompatible with this model, we suggest that differences in diet between individuals will account for the apparent spread of radiocarbon ages. Applying the Bayesian mixing model FRUITS (Food Reconstruction Using Isotopic Transferred Signals) to the stable isotope data, we will then use the estimated contributions of marine and freshwater food groups to $\delta^{13}C$ to correct the calibrated radiocarbon ages, thereby producing a more accurate combined estimate of the burial date.

SESSION 4A, Thursday June 22nd

Universal applications

Amorphous food remains – radiocarbon dating and paleodiet reconstruction

Organized by: John Meadows and Linda Cummings

This session welcomes archaeological and experimental case studies that explore the complexity and versatility of isotopic and biomolecular signatures in amorphous food remains, such as food crusts on pottery. In particular, we invite studies which

- attempt to quantify the contributions of different carbon reservoirs to the 14C ages of different chemical fractions
- identify and correct radiocarbon reservoir effects in food remains using isotopic and biomolecular techniques
- reconstruct past cuisine and/or diet using these techniques
- use radiocarbon reservoir effects as a marker of aquatic ingredients
- use compound-specific or bulk analyses, or compare both
- explore the effects of food preparation or diagenesis on radiocarbon ages, isotope ratios and biomarkers

Food Chemistry to Lab Chemistry: the Importance of Both in Obtaining Accurate Radiocarbon Dates from Charred Food Crust

Linda Scott Cummings

(PaleoResearch Institute, Golden, CO), R. A. Varney (PaleoResearch Institute, Golden, CO), Thomas W. Stafford, Jr. (Stafford Laboratories), Jeff Speakman (CAIS, University of Georgia), and Donna C. Roper (KSU, deceased)

Dating charred food crust presents unique challenges. The carbon content in charred food crust or ceramic residue can be a combination of carbohydrates from land plants and proteins and fats/lipids from either land or aquatic animals. Occasionally wild rice and/or other aquatic plants contribute carbohydrates to the food pot. Pyrolysis is the process of forming a golden-brown (or darker) crust in carbohydrates or protein when cooked. Since pyrolysis does not occur in the presence of water, the food compounds that rise above the water level to the neck or rim of the vessel is the most likely to char.

Non-enzymatic browning typical of pyrolysis and the Maillard reaction, between amino acids and reducing sugars, proceeds rapidly between 140 and 165°C. Caramelization and pyrolysis become more pronounced at higher temperatures (Maillard 1912; Chichester 1986). Only relatively low temperatures (around 140 or 150°C) are necessary to char carbohydrates including starch, which rise to the top of the water column when boiled, then are transported to the dry neck and rim of ceramic vessels by carbohydrate-rich froth. The neck and rim of ceramic vessels obviously attain sufficient heat to char carbohydrates, as charred food residue is observed in this portion of vessels. Vessels containing food char on the interior bottom likely have been allowed to boil dry or represent foods cooked largely without water. In areas where maize is known to have been used, phytoliths from maize cobs/cupules have been recovered in charred food residue recovered from the rim and outside of the neck of ceramic vessels, providing further evidence of charred food residue in these locations. This apparent separation of food compounds during cooking offers a unique opportunity to apply chemical methods to separate the more completely charred carbohydrates from the less charred proteins and uncharred fats/lipids.

Development of a chemical pre-treatment protocol in the laboratory prior to radiocarbon dating charred food crust has met with considerable success. Using a mixture of polar and non-polar solvents (chloroform and methanol) prior to the typical acid-base-acid protocol usually separates the thoroughly charred carbohydrates from the less charred proteins and amino acids and uncharred animal fats/lipids, allowing their removal.

Aquatic animal foods, such as fish, obtained from fresh water are expected to have incorporated ancient carbon into their systems when dissolved inorganic carbon (DIC) is present in the water system, thus contributing ancient carbon to ceramic vessels and food residues. Dating both untreated and treated charred food crust removed from ceramics indicates this protocol removes food compounds (fats/lipids and proteins) containing ancient carbon, producing radiocarbon dates concurrent with dates obtained on associated charred terrestrial annuals. In addition, dating dried fish caught in 1939 and modern fish and wild rice caught and harvested in 2015 reflects the presence of dissolved inorganic carbon in quantities that vary across the landscape. Trophic levels of fish, reflecting their diet, impacts the degree of offset from the target date.

EA-IRMS and ^{14}C reservoir effects in food crusts: when are the results useful?

John Meadows[1,2], H Piezonka[3]

[1] Centre for Baltic and Scandinavian Archaeology (ZBSA), Schleswig, Germany
[2] Christian-Albrechts University, Leibniz Laboratory for AMS Dating and Stable Isotope Research, Kiel, Germany
[3] Christian-Albrechts University, Institute of Pre- and Proto-History, Kiel, Germany

Stable isotope data (δ^{13}C and/or δ^{15}N) have long been used to support dietary reservoir effect corrections of ^{14}C ages from human bone samples, on the basis that terrestrial and aquatic species often have distinct isotopic signatures. The accuracy of such corrections depends on how well the relevant parameter values (e.g. baseline stable isotope and ^{14}C signatures) are known, as well as on the quantitative modelling methods applied, but several recent case studies have shown that it is possible to calculate corrections that are consistent with dietary reservoir effect estimates derived from comparison with contextual dates. Where the parameter values are poorly constrained, the logic can be reversed, using linear regression of ^{14}C age offsets between human bone samples and contextual dates to establish the relationship between stable isotope results and dietary reservoir effects. This approach allows reservoir-effect correction for human remains without contextual dates, and provides better estimates of parameter values.

There is increasing evidence that charred food crusts on pottery used by hunter-gatherer-fisher societies often contain carbon derived from aquatic food chains, resulting in misleadingly early ^{14}C dates. Food-crust isotopic signatures have been used to gauge the risk that their ^{14}C ages may be subject to marine or freshwater reservoir effects, but uncertainty about potential shifts in δ^{13}C and δ^{15}N during and after charring, and natural variability in baseline parameter values, would appear to rule out using EA-IRMS data to estimate reservoir-effect corrections. Moreover, perfectly paired ^{14}C samples (of food-crusts and exactly contemporaneous terrestrial organisms) to provide independent estimates of food-crust reservoir effects are seldom available.

Nevertheless, a Bayesian chronological modelling approach does not require exact contemporaneity in order to estimate ^{14}C age offsets, and in certain circumstances, it is possible to apply linear regression to food-crust data, and to thereby obtain credible estimates of parameter values. This suggests that food-crust EA-IRMS data may be more informative than previously assumed, which would imply that fractionation and diagenesis may not be as problematic as expected. We use archaeological and simulated ^{14}C and EA-IRMS data to model the relationship between sample values and the proportions of terrestrial and aquatic ingredients in food crusts, in order to better understand the usefulness of food-crust EA-IRMS results in detecting and quantifying ^{14}C reservoir effects.

Documenting Ancient Carbon in Bones and Plant Cells

Linda Scott Cummings

(PaleoResearch Institute, Golden, CO), R. A. Varney (PaleoResearch Institute, Golden, CO), Thomas W. Stafford, Jr. (Stafford Laboratories), Jeff Speakman (CAIS, University of Georgia), and Donna C. Roper (KSU, deceased)

Understanding the components of food underpins understanding dates on charred food crust. Dates reported on ceramic residue or charred food crust over the past several decades have been acknowledged as “not accurate” or “too old”. Therefore, irrespective of individual dates on charred food from archaeological sites, reference studies must be completed on foods common in areas known to have produced anomalous dates on any form of archaeological food residue. Building on reported anomalies, whether acknowledged as inaccurate or reported as the “earliest” dates of a culture, it has become imperative to understand the carbon constituents of food. Philipssen (2015) reported a date of approximately 800 BP on *Alces alces* bone from an animal killed that season. Typically bones from land-dwelling animals have been considered to date age-appropriate. This example indicates the diet of land animals has the potential to introduce ancient carbon into their bodies and, hence, the radiocarbon record.

Aquatic animal foods, such as fish, obtained from fresh water are expected to have incorporated ancient carbon into their systems when dissolved inorganic carbon (DIC) is present in the water system, thus contributing ancient carbon to ceramic vessels and food residues. Dating dried fish caught in 1939 and modern fish and wild rice caught and harvested in 2015 reflects the presence of dissolved inorganic carbon in quantities that vary across the landscape. These dates are compared with a water hardness map. Trophic levels of fish, reflecting their diet, impacts the degree of offset from the target date and are discussed. Fish that feed on aerial bugs have less depleted carbon stores than bottom feeders.

SESSION 4B, Thursday June 22nd

Universal applications

Palaeodiet reconstructions and chronologies

Organised by: Jesper Olsen, Marie Kanstrup, Bente Philippsen.

Marine and freshwater reservoir effects often complicate good archaeological chronologies. This session will focus on using stable isotope diet reconstructions to provide information on marine or freshwater reservoir effects, which ultimately may aid improving radiocarbon chronologies.

Meat resources in the human diet and the radiocarbon chronology of the Turganic site (Ural region)

Nina Morgunova[1], N Roslyakova[2], M Kulkova[3], L Nesterova[3]

[1] Orenburg State Pedagogical University, Orenburg, Russian Federation
[2] Samara State University of Social Sciences and Education, Samara, Russian Federation
[3] Herzen State University, St.Petersburg, Russian Federation

The Turganic site was excavated during the 1981-1982 and 2014-2015. There are two cultural layers on this site. The earlier cultural layer belongs to the Eneolithic period (Samara culture) and the later layer is the cultural layer of Bronze Age (earlier stage of Yamnaya culture).

The species composition of animal bones from the Turganic site allows us to assess the diet of ancient people. During the Eneolithic period meat resources consisted mainly of the domestic ungulate animals. Cattle, small cattle and probably the horse were the main animals for cattle breeding in this period. The hunting was the supplemental type of economy. In the Early Bronze Age the species composition of animals did not changed. The comparison of Eneolithic bone collections with the collections of the Early Bronze Age allows us to consider the variation in the meat diet of people occupied this site. There is the tendency in decreasing of wild animal species and the increasing of small cattle. The age assessment of cattle slaughter shows people begin to practice the transhumant system of cattle breeding.

The series of 32 radiocarbon dates on animal bones and on organics from pottery was obtained from different parts and stratigraphic layers of site. The dates were divided on three groups on the base of archaeological material. The group I includes 11 of 14C dates. The dates are in the interval from 5206 to 4361 cal BC. This is the chronological period of the early and developed stages of the Samara culture. The next time interval (from 4237 to 3790 cal BC) corresponds to the group II including 6 radiocarbon dates. The late stage of Samara culture is dated by this period. The group III (12 of 14C dates) includes the dates on the organics from the pottery of Repinsky type of Yamnaya culture and on animal bones from the layer of Bronze Age. The dates of these artifacts lay in the interval from 3786 to 3105 cal BC.

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Diet and chronology of the neolithic cultures in the low povolzhye

A Vybornov[1], Marianna Kulkova[2], P Kosintsev[3], B Philippsen[4]

[1] Samara State University of Social Sciences and Education, Samara, Russian Federation
[2] Herzen State Pedagogical University, St.Petersburg, Russian Federation
[3] Institute of Plant and Animal Ecology, Urals Branch of the RAS, Yekaterinburg, Russian Federation
[4] Radiocarbon Dating Center, Aarhus University, Aarhus, Denmark

Several Neolithic sites with clear stratigraphy of cultural layers containing an ancient pottery have been excavated in the Low Povolzhye in recent years. Animal bones and organic remains which were found in the cultural layers were used for diet reconstructions and Neolithic chronology. The identification of animal bones allowed the detailed reconstruction of the meat component of the diet. Fish bones indicate the consumption of freshwater. Onager, saiga antelope, red deer, aurochs, wild-boar, corsac fox, wolf, birds and fish were found in Kairshak type sites of the Seroglazovskaya culture (Baybek, Kairshak-III sites) in the North Caspian Sea region. The dog is the only example of domestic animals. Fifty radiocarbon dates were obtained for this culture. Most of the dates lay in the interval from 6500 to 5900 calBC. Dates on shells are 500 years older. Remains of onager, saiga antelope, red deer, aurochs and tarpan are present at sites of the Tektensor type. Bones of domestic sheep were not found at these sites. Fifteen radiocarbon dates in the interval from 5900 to 5400 calBC were obtained for this cultural type. Also in this case, the dates on shells are 500 years older.The cultural layers of the sites of the Djangar culture, located in the North-Western Caspian region, yielded the bones of saiga antelope, onager, gazelle, tarpan, aurochs, red deer, corsac fox and wild-. Data on the domestic horse was not confirmed. Ten radiocarbon dates lay in the period from 6000 to 5500 calBC.

In the steppe Povolzhye, in the sites of the Orlovskaya culture (Algay, Varfolomeyevka), bones of tarpan, onager, aurochs, saiga antelope,wolf, corsac fox, red deer, bird and fish were identified. Fifty radiocarbon dates were obtained for this cultural type. Most dates lay in the period from 6200 to 5400 BC. Dates on charred crusts on pottery sherds, animal bones and charcoal agree with each other. The dates on fish bones are 1000 years older.

In the Low Povolzhye region, at sites belonging to the Caspian Sea region cultures (Oroshayemoye I, Kurpezhe sites), remains of saiga antelope, onager, tarpan, aurochs and wild-boar were identified. Sheep and goats were determined as domestic animals. This is the first evidence for producing economy in Povolzhye. There are ten radiocarbon dates for this cultural type from 5500 to 4800 calBC. The AMS dates on the bones and organics from pottery have a good correlation. For the Khvalinskaya culture, in the cultural layers of Kombakte, Kairshak VI sites. the Onager, saiga antelope, tarpan, red deer and corsac fox were found. Dogs, sheep and cattle were identified as domestic animals. Twenty radiocarbon dates, from 5000 to 4600 calBC, were obtained. Interestingly, human bones from these context have older ages. The results of lipid analysis of charred food crusts on the pottery from several sites showed that the meat and plant food prevailed in the dietof people in this region.

These results allow for the first palaeodietary reconstructions of people of different cultures in the Low Povolzhye. The large number of radiocarbon dates gave the possibility to establish the precise chronology for these cultures.

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Archaelogical materials of Eneolithic settlements in forest-steppe zone of the Volga region: a source for paleodiety and chronology

Marianna Kulkova[1], A Korolev[2], V Platonov[3], N Rosljkova[1], A Shalapinin[1], E Yanish[4]

[1] Herzen State Pedagogical University Department of Geology and Geoecology, St.Petersburg, Russian Federation
[2] Samara State University of Social Sciences and Education Russian History and Archaeology Department, Samara, Russian Federation
[3] Samara University Department of Chemistry, Samara, Russian Federation
[4] Schmalhausen Institute of Zoology Department of Animal Monitoring and Conservation, Kiev, Ukraine

The study of the Eneolithic economyin the forest-steppe zone of the Volga region is one of the difficult problems. The results of investigation of the economy and diet in this region are presented in this article. For the first time the results of complex investigations of Lebjazhinka VI site are considered. The bones of wild and domestic animals, fishas well as the food crusts on pottery have been studied. The age of materials from this site was determined by the radiocarbon dating.

The development of domestication in the forest-steppe zone of the Volga region can be explained by the appearance of Pricaspian and Khvalinian cultures from southern regions. The bones of small and large cattle were found inthe Khvalinian cultural layers. But the bone has poor preservation in the cultural layers.The faunistic remains were found at the sites of Lebjazhinka III, IV, VI, Chekalino IV, Chesnokovka. These sites are multilayers and there is the problem to coincide the bones with pottery types. The Lebjazhinka III, VI sites have differences from other. The Lebjazhinka III site is one layer site. The house's remains with pottery sherds, stone and bone tools were studied. The bones of wild animals such as elk, roe deer, primitive bull, camel, bear, badger, otter, beaver, hare, turtlewere found as well as the bones of birds and fish. The main food resources of people in this site were the wild animals. This site belongs to the Samara culture and it's age is from 5300 to 4520 cal BC.

The fireplaces, pottery, stone tools and bones were found inside the house's ditchat the Lebjazhinka VI site. There are numerous animal, bird and fish bones as well as the shells. The bones of marten, beaver, elk, bear, wolf, fox, hear, badger, otter, marmot are prevailed among the wild animal bones. The domestic types are presented by cattle (Bostaurus) and small cattle (sheep or goat- Ovisaries/ Capra hircus). There are the bones of horse (Equuscaballus) also. But there is unclear whether they are domestic or wild. The bones of dog were found.

The fish bones are presented by 9 species: Russian sturgeon (Acipenseriformes), stellate sturgeon (Acipenserstellatus), starlet (Acipenserruthenus), carp (Cyprinuscarpio), roach (Rutilusrutilus), zander (Stizostedionlucioperca), perch (Percafluviatilis), pike (Esoxlucius), catfish (Silurusglanis). The bones of postcranial skeleton of fish (PCRA) are prevailed. The predominant amount of bones are pike bones, after that the bones of catfish, carp, zander, perch.

The lipid analysis of the food crusts from 25 fragments of pottery allowed us to determine the cooked food. The meat food was determined for 7 vessels. The fish food was in 14 vessels, and plant food was in 4 vessels. The 14C dates for this house are from 4253±262 to 4084±279 cal BC.

Chronology and diet of the Gravettian humans from Apulia (Italy)

Sahra Talamo[1], MA Mannino[1,2], A Ronchitelli[3], F Boschin[3], D Coppola[4], E Vacca[5], S Ricci[3], F Mallegni[6], MP Richards[1,7]

[1] Max Planck Institute for Evolutionary Anthropology, Department of Human Evolution, Leipzig, Germany
[2] Aarhus University, Department of Archaeology and Heritage Studies, School of Culture and Society, Højbjerg, Denmark
[3] Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente – Unità di Ricerca di Preistoria e Antropologia, Università degli Studi di Siena, Siena, Italy
[4] Dipartimento di Studi Umanistici, Università degli Studi di Bari "Aldo Moro", Bari, Italy
[5] Dipartimento di Biologia, Università degli Studi di Bari "Aldo Moro", Bari, Italy
[6] Dipartimento di Biologia, Università di Pisa, Pisa, Italy
[7] Department of Archaeology, Simon Fraser University, Brunaby, British Columbia, Canada

The prehistoric archaeological record of Apulia in SE Italy comprises a relatively high number of burials attributable to the Gravettian. This middle Upper Palaeolithic culture, which spread across Europe in the millennia prior and around the Last Glacial Maximum, possessed sophisticated hunting capabilities, but also technologies and knowledge for the exploitation of the broad spectrum of available resources, including plants. Despite the importance of Gravettian burials, very few of them have been directly dated. In this paper we present the results of AMS radiocarbon dating on well-preserved bone collagen extracted from the skeletal remains of the hunter-gatherers buried at the Apulian cave sites of Grotta Paglicci (Rignano Garganico), Grotta di Santa Maria di Agnano (Ostuni) and Grotta delle Veneri (Parabita). These dates will be placed within the chronologies available for the respective sites and for the Italian Peninsula in the run up to the Last Glacial Maximum. In addition, carbon and nitrogen isotope analyses, conducted as part of the radiocarbon dating work on the bone collagen, provide original data on the diet of these hunter-gatherers. This method of dietary reconstruction is biased towards the protein component of the diet and, overall, shows that Gravettian groups in Apulia consumed large proportions of meat originating from terrestrial herbivores. Variability between individuals, however, is present in their nitrogen isotope compositions and we explore if this is due to changing environmental conditions or to the exploitation of aquatic resources by some of them.

Open access data for chronological and dietary analysis

Christopher Bronk Ramsey

University of Oxford, Research Laboratory for Archaeology and the History of Art, Oxford, UK

Individual studies involving chronology and diet can in themselves be transformative. However, frequently the greatest long term impact comes from the synthesis of information from a range of geographical regions and periods. For this to be possible it is essential that data is shared in a form which enables reanalysis in new ways, perhaps unforeseen by the authors of the original research. The advent of databases where dietary information can be deposited is a welcome step in this direction. However, databases frequently only store one type of information and can themselves be limiting in their scope. For this reason, interconnectedness of both data sources and tools for analysis are very important. This allows information stored in a distributed way to be used in innovative ways.

These are the motivations behind current developments of a number of related tools. The INTIMATE chronological database tools and OxCal are being transformed so that they can work better with databases (such as ISOMEMO and radiocarbon databases), other tools (such as FRUITS) and generic packages (such as R and Python). The aim is that a researcher in the future should be able to fairly seamlessly start off a new analysis using the output of existing publications without having to spend a lot of time and resources simply reassembling the data. The key elements to making this possible are: easy archiving of structured information on publication in databases or other data depositories, and tools which enable this data to be quickly assembled and reanalysed. In order to make authors and researchers keen to do this, and to provide traceability for quality control, it is essential that the data is tagged with the publication information so that credit can be given to those producing the primary data. In practice, it will also require the capability of third parties to pull together legacy data into one of the required formats.

The combination of chronology and diet provides particularly difficult challenges in that there needs to be a good structured linkage between the chronological, isotopic and other information. This is far from straight-forward since there is rarely a one-to-one relationship between dates and dietary information. However, if this can be done properly there is the opportunity to transform the practice of this form of scientific research.

Hunter-gatherer mortuary practices in the shell middens of the Tagus and Sado valleys, Portugal, through the lens of radiocarbon and stable isotope analyses

Rita Peyroteo Stjerna[1,2], M Diniz[2], AC Araújo[3,4]

[1] Uppsala University, Department of Organismal Biology, Uppsala, Sweden
[2] University of Lisbon, UNIARQ - Centro de Arqueologia, Lisbon, Portugal
[3] DGPC - Laboratório de Arqueociências (LARC), Lisbon, Portugal
[4] CIBIO/InBIO - Centro de Investigação em Biodiversidade e Recursos Genéticos, Vila do Conde, Portugal

In this paper we present new radiocarbon and isotopic data ($\delta^{13}C$, $\delta^{15}N$) on human bone collagen of 50 individuals buried in the shell midden sites of the Tagus and Sado valleys, Portugal. Here, in the south-western Atlantic coast of Europe the rise of sea levels during the Atlantic climatic optimum (ca. 8350–6300 cal BP) resulted in the formation of large estuaries. Today, far from the sight and influence of marine waters, these late Mesolithic shell middens can be very large archaeological sites, many of them with well-preserved human remains.

The new isotopic data supports previous evidence of an overall mixed diet from aquatic and atmospheric reservoirs. However, while the individuals buried in the Tagus valley show a strong marine diet component, ca. 100 km south, the hunter-gatherers of the Sado valley show a diet intake almost exclusively from atmospheric reservoirs. Furthermore, the new isotopic data seems to suggest that groups of middens may be the burial ground of distinct groups, at least on a dietary level.

Ongoing geoarchaeological analysis suggests that dietary diversity could result from environmental constraints along the river valley. But, is the new data indicative of regional identities as well? Or, could the individuals with terrestrial diet originate from interior regions and were buried by the river like the mixed diet groups?

Here, we present a case study where isotopic data opened up to new interpretative scenarios for the study of the mortuary practices of this archaeological population, whose diversity – real or apparent – will be discussed.

Tracking humans: a bio-archaeological approach to the history of pre-historic populations in the Dogon country, Republic of Mali

Nonhlanhla Dlamini[1], A Mayor[1], I Hajdas[2], J Sealy[3]

[1] University of Geneva, Department of Genetics and Evolution, Geneva, Switzerland
[2] Swiss Federal Institute of Technology (ETHZ), Zürich, Switzerland
[3] University of Cape Town, Cape Town, South Africa

Human skeletal remains (n = 220), found buried in 9 caves from the Bandiagara Escarpment in Mali, were studied in order to investigate the dynamics of what life was like during pre-historic times for pre-Dogon and early Dogon people. Accelerated mass spectrometry (AMS) radiocarbon (14C) dating was used to establish chronologies for these burials because there is a lack of stratigraphy in the caves, as well as to understand the history of use of these caves. Stable carbon and nitrogen isotope analyses of the dentine (n = 210) were also done to reconstruct the diet of these past communities.

New AMS 14C dates (n = 84) from the human remains demonstrate a continuous chronological sequence for the burials from the 7th c. AD to the 19th c. AD, proving longer and older use of these cave sites than previously thought. The widespread distribution of carbon (-14.2 to -6.0‰) and nitrogen (6.0 to 14.8‰) isotope ratios at the different burial sites suggests high variation in diets. Carbon isotope ratios indicate both a change in diet through time and different diets between pre-Dogon and Dogon people, which could be explained by a change in climate leading to a heavier reliance on C_4 grains. Nitrogen ratios suggest either a climate effect (drier and hotter climate around 16th c. AD) or a higher protein intake by the early Dogon.

These preliminary results suggest that diets were varied through time, space, and between communities. The data, however, need to be considered for radiocarbon reservoir effects, especially since some of these people are known to have consumed aquatic foods.

Radiocarbon dating on human skeletal remains from Inariyama shell mound of the Jomon period in Japan

Soichiro Kusaka[1], Y Yamada[2], M Yoneda[3]

[1] Museum of Natural and Environmental History, Shizuoka City, Japan
[2] National Museum of Japanese History, Sakura City, Chiba, Japan
[3] University Museum, The University of Tokyo, Tokyo, Japan

The hunter-gatherers of the Jomon period in Japan would have adapted to climatic and environmental changes through time. Carbon and nitrogen stable isotope analysis of human skeletal remains from the Inariyama shell mound of the Final Jomon period (ca. 3000–2300 years BP) have revealed large dietary variations in the population. Here, we show radiocarbon dating on twenty-nine individuals to test whether the dietary variation relates to temporal change. The radiocarbon ages of Inariyama ranged ca. 3250–2130 cal BP and showed three peaks of occupation. In the early and late phases, terrestrial resource consumption and incisor extraction were observed, while marine resource consumption and canine extraction were observed in the middle phase. These temporal changes of diet and tooth ablation types occurred in parallel with climatic cooling and environmental change. These changes might be the result of ecological and cultural responses of Holocene hunter-gatherers to the changing environment.

Agro-pastoral diets in southern Italy from the Neolithic to the Bronze Age

Fabiola Arena[1], MA Mannino[2,3], B Philippsen[4,5], M Kanstrup[4], J Olsen[4], E Gualdi-Russo[1]

1 University of Ferrara, Department of Biomedical and Specialty Surgical Sciences, Ferrara, Italy
2 Aarhus University, Department of Archaeology and Heritage Studies, Højbjerg, Denmark
3 Max Planck Institute for Evolutionary Anthropology, Department of Human Evolution, Leipzig, Germany
4 Aarhus University, Aarhus AMS Centre, Department of Physics and Astronomy, Aarhus, Denmark
5 Aarhus University STAR (Science and Technology in Archaeological Research), Department of Archaeology, Aarhus, Denmark

The period from the Neolithic to the Bronze Age was a time of considerable socio-cultural and economic change, which affected human diets. To improve our understanding of dietary change in communities living in the south of Italy during this period, we have undertaken stable carbon and nitrogen isotope analyses on human bone collagen and AMS radiocarbon dating of individuals whose chronology needed to be verified. The skeletal remains investigated are from the regions of Calabria (Grotta della Monaca, Grotta di Donna Marsilia, Grotta dell'Antenato, Grotta di Sant'Angelo, Grotta du' Scuru), Basilicata (Murgia Timone, Grotta Funeraria and Toppo d'Aguzzo) and Apulia (Ipogeo dei Bronzi). Carbon and nitrogen isotope analyses inform us mainly on the intake of dietary protein, although, in diets characterized by limited meat consumption, they also provide us with information on plant consumption. In particular, this method of palaeodietary reconstruction allows us to establish the ecosystem of origin of foods (terrestrial, freshwater and/or marine) and the type of diet (vegetarian, omnivorous or carnivorous). Our analyses on 33 human and 12 faunal bone collagen extracts attest that the diets of prehistoric southern Italians were mixed and based on the consumption of terrestrial resources, including generally moderate proportions of animal protein (e.g. meat and dairy products) and isotopically-detectable proportions of C3 plants (e.g. cereals and legumes). Slight differences in the proportion of meat consumed may have been present, depending on regional environments, with individuals from Basilicata relying more on animal protein than those from Calabria and Apulia. Contrary to what has been shown for northern Italy, our data suggest that C4 plants (e.g. millet) were probably not consumed by Bronze Age people in the south of the Italian peninsula. By combining stable isotope analyses and bioarchaeological investigations of diet-related dental patterns (wear, microwear, caries, calculus, chipping and hypoplasia of tooth enamel), we have gained insights into the dietary habits of southern Italian populations during the prehistoric period that saw an increase both in agriculture and pastoralism.

Possible wild boar management during the Danish late Mesolithic. An isotope study of red deer, roe deer and wild boar.

Rikke Maring, F Riede

Aarhus University, Department of Archaeology and Heritage Studies, Højbjerg, Denmark

This poster presents a stable isotope and radiocarbon study on a total of 85 samples of wild boar (Sus scrofa), human (Homo sapiens), dog (Canis familiaris), red deer (Cervus elaphus) and roe deer (Capreolus capreolus) from four Late Mesolithic sites in Jutland, Denmark. Two shell middens; Fannerup F and Nederst from the Djursland peninsula and the two sites; Yderhede and Østenkær from the northern part of Vendsyssel. All $\delta^{13}C$ and $\delta^{15}N$ values of the red deer, roe deer and wild boars were comparable and matched our expectations of the diet of animals living in a terrestrial environment dominated by C_3 plants. The indication is, that they all lived under similar environmental conditions during the Ertebølle period. Except for the values of four wild boars from the site Fannerup F. Their $\delta^{13}C$ values ranged from -21.5 to -11.7 ‰ while $\delta^{15}N$ values ranged from 4.5 to 12.6 ‰. These isotope values are noticeably enriched compared to those of the deer from the same site and other wild boars dated to the Ertebølle period in Denmark. The $\delta^{13}C$ and $\delta^{15}N$ values indicate that at least 50% of the wild boars' dietary proteins derive from marine food sources, possible by foraging on marine leftovers.

Contrary to common interpretations of Late Mesolithic animal economy, we claim that people of the Ertebølle site Fannerup F, at least to some extent, managed wild boars in a similar way to how dogs were kept, considering that the $\delta^{13}C$ and $\delta^{15}N$ values of the four wild boars are comparable and almost identical to that of contemporary dogs. We do not claim to understand the extent and character of management completely. The ^{14}C dates of the four wild boar range from 5290-4335 cal BC, suggesting that the management of wild boar was sustained over a significant time-scale, and even began before the introduction of pottery.

Although sample size remains small, the existence of enriched values suggests that we must reconsider our interpretation of Late Mesolithic animal management.

Paleodiet and radiocarbon dating to study the social complexity in peasant societies of the early medieval rural communities north-western Iberia

Paola Ricci[1], JA Quiros Castillo[2], C Lubritto[1]

[1] University of Campania "l. Vanvitelli", Department of Environmental Science and Technology, Caserta, Italy
[2] University of the Basque Country, Department of Geography, Prehistory and Archaeology, Vitoria-Gasteiz, Spain

In the last twenty years there has been the discovery of an incredible number of low intensity rural settlements spread across wide areas and related to peasant communities in different historical periods and territorial contexts.

The main objective of this paper is to contribute to the analysis of the social and political complexity of local early medieval societies in north-western Iberia, through the study of the archaeological, archaeozoological and isotopic records of peasantry communities.

The work intends to explore the possibilities of studying inequality in early medieval communities by establishing what these forms of inequality were and how they can be seen in material terms. The identification of 'social and economic signatures' is based on the study of a wide range of material records (human bones, fauna sample, archaeobotanical species) and their contextual analysis.

Our attention is focused on the use of stable isotopic signatures and radiocarbon dating as a passive reflection of inequalities in local societies, but also as an active instrument for building identities and inequalities within communities. In particular, the theoretical starting concept is that access to food is conditioned by economic position and that is normally linked to social status. Therefore isotopic studies of human remains allow us to identify the eating patterns of specific individuals taking into consideration variables such as status, gender, age and lifestyle.

Three indicators derived from isotopic analyses for the identification of social inequality are proposed: i) the comparison of standard deviations as a marker of homogeneity or heterogeneity within a community; ii) $\delta^{13}C$ values for the identification of the type of plants consumed, which are linked to the productive strategies adopted; iii) $\delta^{15}N$ values for the detection of differences in the access to protein resources.

With these goal, and in order to well establish baseline data, zoarchaeological analyses of potential food plants and isotopic signature of fauna and plants from the study region, have been performed.

In detail, the zooarchaeological remains recovered in various early medieval rural settlements located in the Basque Country has been examined and compared, in order to explore possible signs of economic complexity and social differences between sites. Through the analysis of the percentages of the domesticated species, the diversity of wild species and the kill-off patterns, it is

suggested that social inequalities and complex economic activities existed at the examined sites.

The analysis of human samples reveals diet was mainly based on C_3 plants and restricted intake of animal protein, even if presence of C_4 plants has been found. On the other hand isotopic analyses of domestic fauna from the settlement provide new insights into productive strategies,

especially the integration between arable farming and husbandry. The analysis of an assemblage of domestic animals confirmed the diversified nature of livestock management, including grazing on manured pastures and foddering on C_4 plants.

Moreover the existence of peasant strategies of productive diversification has been analysed investigating the consumption of C_4 plants in different sites studied. The most interesting outcome is the identification of small but regular consumption of C_4 plants by a considerable part of the population, which can be interpreted in terms of diversification and control of the production by peasants.

Other interesting results coming from the isotopic measurements is that the community members, whether they were buried with or without grave goods, had a similar diet. That is, social inequalities were not shown in different eating patterns or the social distances were much shorter than can be inferred from the items of metalwork used as funerary objects.

Freshwater reservoir effect variability in Dendermonde (Flanders, Belgium)

Marco Bonafini[1], M Boudin[1], W Van Neer[2], A Ervynck[3]

1 Royal Institute for Cultural Heritage, Brussels, Belgium
2 Royal Belgian Institute of Natural Sciences, Brussels, Belgium
3 Flanders Heritage Agency, Brussels, Belgium

When dealing with archaeological human remains from Belgium dating from the Roman and younger periods, the consumption of both marine and freshwater fish has to be taken into account. The reservoir age of marine fish of the North Sea is known (400 years) but the reservoir age of the Belgian rivers was never studied before. Therefore, ^{14}C and stable isotope ($\delta^{13}C$ and $\delta^{15}N$) analyses were performed on freshwater fish bones found in a cesspit from Dendermonde (16th century) in order to determine the reservoir age, its variability over time and inter – and intraspecies variability.

Stable isotope analysis of the Early Iron Age sites of Central Kazakhstan (Tasmola Culture, Korgantas and Karamola Periods)

S Svyatko[1], A Beisenov[2]

[1] [14]CHRONO Centre for Climate, the Environment, and Chronology; Queen's University Belfast, Belfast, UK
[2] Institute of Archaeology n.a. A. Kh. Margulan, Almaty, Kazakhstan

Tasmola Culture (8th-5th c. cal BC) was spread in Central Kazakhstan among populations of Saka period (Early Iron Age). According to the archaeological data, the tribes were adapted to sharply continental climate of arid steppes in the Kazakh Uplands; they led a pastoral lifestyle with regular seasonal migrations. Tasmola people also mastered metallurgy and metalwork, as well as jewellery crafting. In many ways, this culture was close to synchronous communities of the Eastern Eurasian Steppe – those from Southern Siberia, Zhetysu (South-Eastern Kazakhstan), Northern Kazakhstan and Eastern Pre-Aral Region. From anthropological data, Tasmola tribes of Central Kazakhstan apparently descended from mixed Andronovo-type population of the Bronze Age.

Tasmola monuments were succeeded by the Korgantas type burials. At the moment, only about 40 monuments of this type are known in the region, and they are dated to the 4th-2nd c. BC. The appearance of Korgantas burials was likely related to the arrival of a new population from eastern regions of Central Asia, in particular, early Hun (Xiongnu) groups. The investigation of Karamola cites in the area has only recently started and only few cites are known.

This study presents stable isotope analysis of 27 individuals of the Tasmola Culture, 4 individuals of the Korgantas Period, 2 individuals of the Karamola Period, and 13 faunal samples from a number of Early Iron Age sites of Central Kazakhstan.

Stable carbon and nitrogen isotope analysis suggests that the diet of the population was generally based on C_3 resources, largely on domestic stock. Climatic trends are also obvious from the results, namely – from the positive correlation between the two isotopes, both in humans and fauna. Four individuals from sites of Koitas (kurgan 1), Taldy 2 (kurgan 2), Akbeit 1 (kurgan 1) and Karashoky (kurgan 1), all AMS radiocarbon dated to the 7th-6th c. cal BC, indicate the consumption of various amounts of C_4 plans, likely millet. The latter is not unexpected given that, from the previous isotopic research, millet consumption has been detected in south-eastern Kazakhstan since 16th c. cal BC. It is yet somewhat surprising that only several individuals of the Tasmola Culture, and apparently none of the later Korgantas and Karamola Periods demonstrated the consumption of C_4 plants. The recent data from e.g. Karatuma site located in South-Eastern Kazakhstan and dated to the 4th-2nd c. BC suggests that the majority of the population was engaged into C_4 (millet) consumption.

First data on diet of the Neolithic – Eneolithic populations of the Trans-Urals and Central West Siberian plain

Yaroslav Kuzmin[1,2], J van der Plicht[3], V Panov[4], N Chairkina[5], T Klementieva[5], A Pogodin[6]

[1] Sobolev Institute of Geology & Mineralogy, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russian Federation
[2] Laboratory of Mesozoic and Cenozoic Continental Ecosystems, Tomsk State University, Tomsk, Russian Federation
[3] Centre for Isotope Research, University of Groningen, Groningen, The Netherlands
[4] Centre of Cenozoic Geochronology, Institute of Archaeology & Ethnography, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russian Federation
[5] Institute of History & Archaeology, Urals Branch of the Russian Academy of Sciences, Yekaterinburg, Russian Federation
[6] Scientific–Analytical Centre for Problems of the Preservation of Cultural and Natural Heritage "AV KOM – Heritage", Yekaterinburg, Russian Federation

Palaeodietary studies for the Trans-Urals and central West Siberian Plain have not been conducted before. The main cause for this is that in these regions human remains are rarely found. We measured the stable isotopes' ratios ($\delta^{13}C$ and $\delta^{15}N$) and ^{14}C ages for human and animal bone collagen from two sites.

In the Trans-Urals, two bones were found in 1991 by V.A. Arefyev at the famous Gorbunovo wetland site (59.97° N, 57.83° E) on the surface of a dump following the excavation at Cutting IV-A. These human remains cannot be assigned to particular cultural component, but their ^{14}C dates of ca. 5170–5230 BP (ca. 3900 – 4100 cal BC) suggest the Eneolithic (Copper Age) (Chairkina et al. 2013, 2017). The bones show excellent collagen quality, with average stable isotope values $\delta^{13}C$ = -20.5 ‰ and $\delta^{15}N$ = +11.7 ‰.

In the central West Siberian Plain, the Bolshaya Umytya 9 site in the Konda River basin (60.65° N, 63.90° E) belongs to the Early Neolithic, based on artefact typology (stone tools and pottery). Two burials were excavated, dated to ca. 6770 BP (ca. 5700 cal BC) (burial 3) and ca. 5510 BP (ca. 4350 cal BC) (burial 1). Also here the bones show excellent collagen quality, with similar stable isotope values: $\delta^{13}C$ = -21.0 ‰ and $\delta^{15}N$ = +13.7 ‰.

These data indicate the consumption of a mixture of aquatic food and terrestrial animals. Archaeozoological data for the Trans-Urals show the presence of beaver, waterfowl, and fish during the Neolithic and Eneolithic, although the main prey species were ungulates (mainly elk, roe deer, and reindeer) (Kuzmin 2013). Less information is known for the forests of central Western Siberia; because the sites are located near rivers and lakes, one can suggest that the fishing must have been an important part of the Neolithic economy.

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Reconstruction of dietary habits and mobility patterns of the assumed founders of the Tegernsee monastery (Southern Bavaria)

Christine Lehn[1], A Nerlich[2], R Fernandes[3,4]

[1] Ludwig-Maximilians-University of Munich, Department of Forensic Medicine, Munich, Germany
[2] Academic Clinics München-Bogenhausen and München-Schwabing, Munich, Germany
[3] Leibniz-Laboratory for Radiometric Dating and Isotope Research, University of Kiel, Kiel, Germany
[4] University of Cambridge, Mcdonald Institute for Archaeological Research, Cambridge, UK

Human teeth and bone residues of two male persons recovered from the church of the Tegernsee monastery, were investigated by comprehensive and multi disciplinary historical and scientific methods (anthropological and palaeopathological methods, radiocarbon and stable isotope analyses, aDNA analysis) aiming at obtaining as much information as possible about their life and health history.

According to historical sources, the two men are the founders of the Tegernsee monastery, probably the natural brothers Adalbert and Otkar, who supposedly lived during the 8th century. However, radiocarbon results put their lifetimes during the mid 7th century which is considerably older than expected. Results of stable isotope analyses of C-N-S indicate a relatively high consumption of fish (marine or freshwater). Modern fish from Lake Tegernsee have relatively high $\delta^{34}S$ values which make it difficult to differentiate between freshwater and marine fish consumption and also a high radiocarbon reservoir effect (ca. 1000 years).

Based also on the very high Sr isotope values measured in both individuals teeth and the results of y-chromosomal DNA analyses it can be concluded that the two men originated from regions in North-western Europe and settled at Lake Tegernsee after adolescence. The differences between the radiocarbon and historical data for the individuals can be explained given the significant dietary radiocarbon reservoir effect of that lake.

Discussing the dietary patterns of indigenous groups in Cerritos through the stable isotope analysis

Ingrid Chanca[1], K Macario[1], R Milheira[2], S Talamo[3], C Borges[2]

[1] Universidade Federal Fluminense, Niterói, Rio de Janeiro, Brazil
[2] Universidade Federal de Pelotas, Pelotas, Rio Grande do Sul, Brazil
[3] Max Planck Institute for Evolutionary Anthropology, Leipzig,, Germany

Cerritos are archaeological sites described as earthen mounds, present along the lowlands of the Pampas biome and La Plata Basin, among Brazil, Uruguay and Argentina. The earthen mounds located at the Patos Lagoon (an estuarine complex), southern Brazil, were built for different functions over time including temporary camps and residential household, refuse disposal areas, ritual places and, perhaps agriculture. From the archaeological record, hearths found on the base of the mounds suggest the beginning of occupation around 2200 cal BP, when the Pontal da Barra swamp was occupied as transient fish camps. After that, there is a clear process of architectural complexity between 1800 and 1200 cal BP. The later period of occupation, according to the radiocarbon dates was approximately 800 cal BP. The reason for the abandonment of the region remains unknown. As a try to identify what have motivated the abandonment of the settlement after only few centuries of systematic occupation and also to describe more precisely the function of the earthen mounds and the habits of the indigenous groups from this region, we decided to construct for the first time an analysis over their dietary patterns by means of stable isotopes. With the $\delta^{13}C$ and the $\delta^{15}N$ data of the main web food resources and 8 individuals, all of them based on collagen and apatite of the bones remains, we shall discuss the dietary pattern of this group. As one of the human bone samples return values which seems to be from a very different paleodiet, we decided to study these data based on Bayesian models using the software FRUITS. Additionally through this software we aim to obtain the fish-protein intake of the individuals and, therefore, accurately determine the FRE on the radiocarbon dating of the human bones, since we have already calculated the R correction for this reservoir in a previous work.

We intend to contribute to the understanding of their behavior and economy, clarifying some questions about some Cerritos dynamics, which includes mobility, exploration of the aquatic environments and settlement, as well as improving the chronology for the Pontal da Barra archaeological complex based on radiocarbon dating.

Dog co-burials in Livs' cemeteries in Late Iron Age

Eduards Plankajs

Institute of Latvian History at The University of Latvia, Riga, Latvia

In every day life dogs were hunting partners, sled tractors, guards, shepherds as well as consumers of surplus of food. In some cases after the death of their owners, they became part of burial offerings and a proof of the social status of the dead and of his relatives.There is a suggestion that the dogs had eaten the same food as the people - rather human food leftovers, like it is observed today.Based on this hypothesis, in the ancient dietary or paleo-diet studies that use the ancient chemical properties of bone, dog bones are often used as substitutes for human bone, where the latter are not available.

The most famous dog burial findings are Vendel and Viking period burials of Vendel, Valsgärde, Landby, Oseberg, Gokstad, etc. places in Scandinavian peninsula, Britain and Denmark. The newest finding mentioned a dog skeleton cut in half that was found in 2010 at Salme II ship burial together with elite warriors from, possibly, Mälaren region in central Sweden. Unfortunately, the majority of the published scientific papers does not provide details of the dog co-burials on in the Eastern region of east coast of Baltic Sea.

The Livs in Late Iron Age inhabited the western part of the present-day Vidzeme region of Latvia, from the Gulf of Riga to the Daugava river. There were found rare dog co-burials as part of particularly high status burials at Livs burial grounds. In Salaspils Laukskola cemetery (10th-13th century) full dog skeletons were found only in 6 graves from more than 600 graves in total, but in 3 others dog heads were found; at Krimulda cemetery - in burials 2, 10, 16 and 39, in addition in burrow 39 were found remains of at least 2 dogs. Bones of dogs were found in Saknīšu-Atvasīšu cemetery (Grave 8 and 10), Salaspils Lipši cemetery (Grave 15) and Ikšķiles Kābeļi cemetery (Grave 3, 19 and 20) as well. In Late Iron Age for Livs' society as well as Germans', dog was one of the main sacred animals used in grave offerings, so the dog burials could reflect Germanic ritual perceptions and influences from Scandinavia, which is strongly seen in Liv's' burial traditions (cremation burials, burials with horses and dogs and typical prestige artefacts of origin from Scandinavia, Rus and Byzantium). Also in Livs' Late Iron Age settlements, for example, in Salaspils Mārtiņsala settlement, quite a few dog bones (4.5% of all animal bones) were found. It can be explained by dog sacrifices as well. Livs' pagan religious practices include making donations of horses by burying their heads under the foundations of residential buildings, which has been discovered in several archaeological excavations.

The main written source about Baltics in the beginning of the 13th century, "The Chronicle of Henry" also mentions sacrifice of dogs and goats: particularly the way, they were killed - by cutting their throat. This encourages to perform the analysis of the cervical vertebrae of the buried dogs (in the cases of a full skeleton with cervical vertebrae having been preserved) with the aim to pay attention to injuries and traumas (probably by incision), which could be left by the sacrificial process.Perhaps also the placement of dogs in the graves served a special role- at the feet of their deceased owner, lying on the side or even on the back.Also dogs found in Livs' female burials together with high status artefacts, allow us to express the hypothesis of some women's high social role in Livs' society, similar to what it could have been in Scandinavia at same time.Finally, it would be interesting to determine the sex of buried dogs and whether

only male individuals or bitches were as well, and whether there is evidence of a coincidence between the gender of the buried owner and that of his or her dog.

Multi-scalar insights into hunter-gatherer-farmer-fisher subsistence and diet: Isotopic and zooarchaeological insights from Neolithic Djursland, Denmark

Bente Philippsen[1], Sarah Pleuger[2], Cheryl Makarewicz[2]

1 Aarhus AMS Centre, Department of Physics and Astronomy, Aarhus University. Ny Munkegade 120, 8000 Aarhus C, Denmark
2 Institute for Prehistoric and Protohistoric Archaeology, Christian Albrechts University, Johanna Mestorf 2-6, D-24118 Kiel, Germany

The Pitted Ware Culture (PWC) in southwestern Scandinavia supported diverse subsistence strategies that drew from both marine and terrestrial food resources. Communities engaged in marine-oriented hunter-gatherer subsistence, crop husbandry and animal herding, or a combination of these strategies. Establishing the relative importance of these varied resources in the diets of PWC people, however, is challenged by poor preservation of bone assemblages, poor chronological resolution and the diversity of subsistence strategies on the different sites. As part of the multidisciplinary project "CONTACT. The Pitted Ware Phenomenon in Djursland and Maritime Relations across the Kattegat in the Middle Neolithic", we investigate the dietary decisions of the PWC at two intersecting temporal scales: long-term subsistence strategies and 'daily' dietary intake as reflected in zooarchaeological record and pottery residues, respectively. We focus our discussion on the site Kainsbakke on Djursland, Denmark. Furthermore, we present isotope data from a series of other sites around the Kattegat. Our integrated data provide a sound baseline for calculating human diets from isotope ratios of human bones. Furthermore, calculating the percentage of aquatic resources enables us to correct radiocarbon dates of food crusts and human bones for reservoir effects.

The chronology of two medieval cemeteries in central Copenhagen

Jesper Olsen[1,2], Hanna Dahlström[2], Bjørn Poulsen[2]

1 Aarhus AMS Centre, Department of Physics and Astronomy, Aarhus University. Ny Munkegade 120, 8000 Aarhus C, Denmark
2 Centre for Urban Network Evolutions (UrbNet), Aarhus University, Moesgård Allé 20, DK-8270 Højbjerg

During the excavation for the new metro in central Copenhagen a previously unknown early medieval cemetery was discovered and excavated at the Town Hall Square. Radiocarbon analysis was conducted on the 9 individuals found in situ, together with 11 individuals from the other early medieval cemetery in Copenhagen, belonging to the St Clemens church. The dates of these individuals proved to be to a large degree contemporary, spanning between c. AD 1050-1150, and are a significant piece of information regarding the early urban settlement of the town. Here the radiocarbon and stable isotopes analysis of the 20 individuals, belonging to the two cemeteries are presented. The stable isotopes revealed consumption of marine fish which is used to correct the radiocarbon analysis for the marine reservoir effect.

Assessing cultivation conditions and variation through stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$) on cereal crops from medieval Odense (Denmark)

Neeke M Hammers

Centre for Urban Network Evolutions (UrbNet), Aarhus University, Moesgård Allé 20, DK-8270 Højbjerg

Stable isotope analysis on plant remains ($\delta^{13}C$ and $\delta^{15}N$) can amongst others provide information on plant cultivation conditions and agricultural practices. Considering the role of plant foods in people's diets, stable isotope analysis on plant remains can also be a useful source of information when interpreting human diets based on carbon and nitrogen isotope values. This study will discuss the use of stable isotope analysis on charred cereal remains from 3 medieval sites in Odense, Denmark (1200-1500 CE). Differences in settlement size, site use, and finds derived from economic and domestic contexts make that these localities are an interesting case study for assessing potential local differences in crop cultivation practices and crop provision. Analyses have been applied to 3 different cereal species; hulled barley (*Hordeum vulgare* var. vulgare), oats (*Avena sativa*), and rye (*Secale cereale*). In medieval times these grain types were used for a variety of food products, including bread, porridge, and beer, as well as for animal fodder.

Where analysis of plant macrofossil remains can provide information on which species were present and how these have been processed at the sites, isotope analyses can add to this knowledge by providing insights in spatial and temporal differences in crop acquisition and cultivation. Differences between cereal crops as a result of growth conditions and agricultural practices that may be impossible to detect morphologically can be reflected in the carbon and nitrogen isotope data. In addition to assessing crop cultivation conditions of cereals through a combined archaeobotanical and isotopic analysis, this study makes it possible to gain more information on the isotope values at the base of the food chain that may influence stable isotope values as measured in humans and animals.

Preliminary results show that there are differences in isotope values between the different crop species, and between the species at the different sites. From the 3 crop species, hulled barley shows the highest variation in $\delta^{13}C$ and $\delta^{15}N$ values. Because of this isotopic variation, and especially the range in $\delta^{15}N$ values, it is important to consider the consumption of plant foods when interpreting human dietary patterns.

Dealing with multiple reservoir effects in human skeletal remains from Rounala, northern Sweden

Jack Dury[1], Markus Fjellström[1], Thomas Wallerström[2], Gunilla Eriksson[1] & Kerstin Lidén[1]

1 University of Stockholm
2 NTNU, Trondheim

The cemetery at Rounala, Northern Sweden,from which 23 distinct humans were identified during excavations in 1880 and 1915, dates according to historic sources to the middle 1500's. At present the radiocarbon dating of bone collagen from 21 crania from the cemetery indicate that some burials may have been interned there as early as the 1200 or 1300's. An understanding of the religious traditions of these individuals, and the Christianisation of the wider region, is dependant on precise calendar dates being calculated. Here, a re-calibration of these radiocarbon dates will be presented with a consideration of both the marine and freshwater reservoir effects and the diets of these individuals. This investigation also falls into on-going research and discussions of Sámi subsistence and settlement patterns. An analysis of previously published and new $\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$ data reveal that these individual's diets were diverse, incorporating marine, freshwater and terrestrial foods, which together influence the individual's radiocarbon dates.

A preliminary study of aboriginal palaeodiet on Prince Edward Island, Canada

Alison Harris[1] and Vaughan Grimes[2]

1Stockholm University and the University of York
2Memorial University of Newfoundland

Aboriginal populations have inhabited Prince Edward Island, on Canada's Atlantic Coast, for almost 10,000 years, but despite the antiquity of human occupation, the island's archaeological past remains poorly understood. Many of the archaeological sites have been lost to agricultural development and coastal erosion, leaving many questions unanswered. Was the island inhabited on a seasonal basis, or year round? What was the role of marine mammals, such as the extirpated Maritime walrus, in the island economy? In the late 1950s, the skeletal remains of 6 aboriginal individuals were discovered in an eroding sand dune in the small community of Blooming Point on the island's Gulf shore. Prior to repatriation, the indigenous Mi'kmaq allowed a bioarchaeological study to be conducted on the remains as the colonial era site represents the only existing aboriginal skeletal assemblage from Prince Edward Island to date, and it was poised to offer crucial information pertaining to Mi'kmaq foodways in the past. We conducted radiocarbon dating, and stable carbon and nitrogen isotope analysis of bulk bone collagen and human hair increments to investigate aboriginal diet and settlement patterns on the island at the beginning of European colonization. While the bulk collagen isotope data indicated that substantial amount of dietary protein was obtained from the marine environment, the δ13C values were higher than expected, leading us to suspect that the Mi'kmaq buried at Blooming Point relied to a greater extent on the benthic or nearshore foodweb, than on pelagic species. The collagen data were less variable than those measured in individuals from a contemporaneous mainland Mi'kmaq population from New Brunswick and the isotope values from hair increments did not reveal significant seasonal variation. We hypothesize that the Blooming Point burials represent a local Mi'kmaq population, and while certain cultural practices may have been shared with Mi'kmaq communities on the mainland, their foodways were specific to the island environmen

Business meeting

Friday 11:35-12:30, June 23rd, Open for all.

- Presentations for hosting Radiocarbon and Diet 3 in 2020.
- Publication of conference proceedings in Radiocarbon
- Discussion: When is the next meeting to take place?

	Radiocarbon and Diet	^{14}C & Archaeology	Radiocarbon	Radiocarbon and the environment	AMS
2017					
2018					
2019					
2020					
2021					
2022					

In the organising committee we have discussed whether or not is a problem that the Radiocarbon and Diet meeting is located in similar years as the Radiocarbon and the environment meeting. This year the two meetings are two weeks apart and surely this has been a problem for some people wishing to attend this meeting. For others coming from overseas maybe this is an opportunity to travel less back and forth as they may attend two meetings during one travel.

We would like to use this opportunity to hear your opinions on this and to bring forward any suggestions or outcomes forward to the Radiocarbon and the environment meeting in Debrecen, Hungary, 3 July – 7 July, 2017. Or simply just to bring any advice forward to those hosting the next Radiocarbon and Diet meeting.

List of participants

Name	Institution	Country
Andrade, Pedro	Universidad de Concepción	Chile
Andresen, Jens-Bjørn Riis	Aarhus University	Denmark
Arena, Fabiola	University of Ferrara	Italy
Bonafini, Marco	Royal Institute for Cultural Heritage- Irpa-kik	Belgium
Claudi-hansen, Lone	Museum Vestsjælland	Denmark
Collins, Matthew	University of York, University of Copenhagen	Denmark
Cummings, Linda Scott	PaleoResearch Institute	United States
Dalby, Søren	Thermo Scientific	Denmark
Demirci, Özge	Arctic Center - University Of Groningen	Netherlands
Dlamini, Nonhlanhla	University Of Geneva	Switzerland
Dury, Jack	Stockholm University	Sweden
Engovatova, Asya	Institute of Archaeology Russian Academi of Sciences	Russian Federation
Eriksson, Gunilla	Archaeological Research Laboratory	Sweden
Etu-sihvola, Heli	University Of Helsinki	Finland
Faivre, Sanja	University of Zagreb, Faculty of Science	Croatia
Fernandes, Ricardo	Cambridge & Kiel Universities	Germany
Fort, Matthew	Illinois State Archaeological Survey	United States
Hamann, Christian	Leibniz-Laboratory, Kiel University	Germany
Hammers, Neeke	Aarhus University	Denmark
Harris, Alison	Stockholm University	Sweden
Heinemeier, Jan	Aarhus University	Denmark
Johannsen, Niels N.	Aarhus University	Denmark
Korolev, Arkadii	Samara State University Of Social Sciences And Education	Russian Federation
Kulkova, Marianna	Herzen State University	Russian Federation
Kusaka, Soichiro	Museum of Natural and Environmental History, Shizuoka	Japan
Kuzmin, Yaroslav	Sobolev Institute of Geology & Mineralogy	Russian Federation
Lee-Thorp, Julia	University of Oxford	United Kingdom
Legzdiņa, Dardega	University Of Latvia, Institute of Latvian History	Latvia
Lehn, Christine	Ludwig-Maximilians-University Munich	Germany
Leonidovna, Nina	Orenburg State Pedagodical University	Russian Federation
Lidén, Kerstin	Stockholm University	Sweden
Llewellin, Madison	Arctic Centre, University Of Groningen	Netherlands
Lübke, Harald	ZBSA - Schloss Gottorf	Germany
Mannino, Marcello	Aarhus University	Denmark
Maring, Rikke	Aarhus University	Denmark
Meadows, John	Centre for Baltic and Scandinavian Archaeology	Germany
Michael, Dimitra	Institute Of Nanoscience And Nanotechnology, Stable Isotope and Radiocarbon Unit,NCSR “Demokritos”	Greece

Name	Institution	Country
Millard, Andrew	Durham University	United Kingdom
Mortensen, Martin	Danish National Museum	Denmark
Nielsen, Nina Helt	Museum Silkeborg	Denmark
Papin, Dmitriy	Altay state university	Russian Federation
Peyroteo Stjerna, Rita	Uppsala University	Sweden
Plankajs, Eduards	Institute Of Latvian History Of University Of Latvia	Latvia
Pospieszny, Lukasz	Institute of Archaeology and Ethnology of the Polish Academy of Sciences	Poland
Ramsey, Christopher	University Of Oxford	United Kingdom
Ritchie Andersen, Lone	Museum Midtjylland	Denmark
Rose, Helene	ZBSA, Schloss Gottorf	Denmark
Scharlotta, Ian	Aix Marseille Univ, Cnrs, Minist Culture & Com	France
Schulting, Rick	University of Oxford	United Kingdom
Seregin, Nikolai	Altai State University	Russian Federation
Sveinbjörnsdóttir, Árný Erla	Institute of Earth Sciences, University of Iceland	Iceland
Talamo, Sahra	Max Planck Institute for Evolutionary Anthropology Department of Human Evolution	Germany
Tishkin, Alexey	Altai State University	Russian Federation
Van Der Haas, Victoria	University Of Alberta	Canada
Vybornov, Aleksandr	Samara State University Of Social Sciences And Education	Russian Federation
Weber, Andrzej	University of Alberta/aix-marseille Universite	France
Whitehouse, Nicki	Plymouth University	United Kingdom
Zariņa, Gunita	Institute of Latvian History at the University of Latvia	Latvia
van der Sluis, Laura	Queen's University Belfast	United Kingdom

Author index