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References

Aktuell

Jansen 2018

Moritz Jansen, *On the use of Cu isotope signatures in archaeometallurgy, A comment on Powell et al.* Journal of Archaeological Science **93** (2018), 211–215.

Cu isotope characterization of copper-based artifacts is a powerful tool used in recent decades to investigate the types of ore smelted in ancient metal production. Within a larger sample set, Powell et al. (2017) have identified a shift from positive d65Cu values obtained for Eneolithic artifacts in the Balkans (5000–3600 BC) to more moderate and negative d65Cu values of Bronze Age artifacts (2500–1000 BC), with a so-called "copper hiatus" between these two periods. Powell et al. concluded that accessible oxidized ore sources in this region were totally exhausted by the end of the Eneolithic period, directly leading to a "hiatus" in copper production. After the "hiatus", starting with the Early Bronze Age, they proposed that sulfide ores were smelted using the Mitterberg process. The current paper addresses some weaknesses of the arguments put forth by Powell et al. and instead argues that Cu isotope ratios must be jointly considered with additional archaeometallurgical and archaeological investigations. Selective changes in preference for metal alloys likely affected the Cu isotope composition. Metallurgical operations using distinct Cu isotope reservoirs can alter the univariate Cu isotope ratio (65Cu/63Cu). Key points that must be considered are the transition from pure copper in the Eneolithic to arsenical copper in the Bronze Age, the co-smelting of distinct ore types, and the co-melting of metals derived from multiple smelting operations or from re-used metal artifacts. Moreover, there is no archaeological evidence for the Mitterberg smelting process in the Balkans during the Early Bronze Age.

Keywords: Cu isotopes | Copper | Smelting | Archaeometallurgy | Mining archaeology

Powell 2018

W. Powell, R. Mathur, A. H. Bankoff, J. John, O. Chvojka, M. Tisucká, A. Bulatović & V. Filipović, *Copper isotopes as a means of determining regional metallurgical practices in European prehistory, A reply to Jansen.* Journal of Archaeological Science **93** (2018), 216–221.

We present a detailed response to the critique by Mr. Jansen of the paper "Digging Deeper: Insights into Metallurgical Transitions in European Prehistory through Copper Isotopes". When we consider Cu isotope ratios of European Eneolithic and Early Bronze Age artifacts in the context of their local geological settings, climates, and archaeological contexts, Mr. Jansen's hypothesis that 63Cu enrichment results from the adoption of fahlore ores is untenable. In both Serbia and Central Europe, the earliest copper production is associated with 65Cu-enriched ores and subsequently produced artifacts yield lower ranges d65Cu. This shift in Cu isotopic composition correlates with the initial use of predominantly hypogene ores, not with variations in their trace element content. Essentially the expanded dataset supports the conclusions that were presented in the original

paperdCu isotopes are an effective means of delineating the transition from oxide-based smelting to methodologically more complex smelting of sulphide ores in prehistoric Europe with its relatively limited production and trade. Mixing did not mask the critical Cu isotope signatures in this setting. Therefore, Cu isotope compositions of artifacts can be used to interpret the mineralogical character of the ores from which they were produced, regardless of their provenance, as long as trade networks remained within a region of similar climatic history.

Keywords: Copper | Isotope | Eneolithic | Bronze age | Metallurgy | Balkans | Central Europe

Amerika

de la Fuente 2018

Constanza de la Fuente et al., *Genomic insights into the origin and diversification of late maritime hunter-gatherers from the Chilean Patagonia*. PNAS **115** (2018), E4006–E4012.

pnas115-E04006-Supplement.pdf

Constanza de la Fuente, María C. Ávila-Arcos, Jacqueline Galimany, Meredith L. Carpenter, Julian R. Homburger, Alejandro Blanco, Paloma Contreras, Diana Cruz Dávalos, Omar Reyes, Manuel San Roman, Andrés Moreno-Estrada, Paula F. Campos, Celeste Eng, Scott Huntsman, Esteban G. Burchard, Anna-Sapfo Malaspinas, Carlos D. Bustamante, Eske Willerslev, Elena Llop, Ricardo A. Verdugo & Mauricio Moraga

Patagonia was the last region of the Americas reached by humans who entered the continent from Siberia ≈15,000–20,000 y ago. Despite recent genomic approaches to reconstruct the continental evolutionary history, regional characterization of ancient and modern genomes remains understudied. Exploring the genomic diversity within Patagonia is not just a valuable strategy to gain a better understanding of the history and diversification of human populations in the southernmost tip of the Americas, but it would also improve the representation of Native American diversity in global databases of human variation. Here, we present genome data from four modern populations from Central Southern Chile and Patagonia (n = 61) and four ancient maritime individuals from Patagonia (≈1,000 y old). Both the modern and ancient individuals studied in this work have a greater genetic affinity with other modern Native Americans than to any non-American population, showing within South America a clear structure between major geographical regions. Native Patagonian Kawéskar and Y¿¢mana showed the highest genetic affinity with the ancient individuals, indicating genetic continuity in the region during the past 1,000 y before present, together with an important agreement between the ethnic affiliation and historical distribution of both groups. Lastly, the ancient maritime individuals were genetically equidistant to a ≈200-y-old terrestrial hunter-gatherer from Tierra del Fuego, which supports a model with an initial separation of a common ancestral group to both maritime populations from a terrestrial population, with a later diversification of the maritime groups.

Keywords: paleogenomics | Patagonia | maritime hunter-gatherers

Significance: Recent genomic studies of ancient and modern humans from the Americas have given a comprehensive view of the peopling of the continent. However, regional characterization of ancient and modern individuals is lacking, being key to unveiling finescale differences within the continent. We present genomewide analyses of ancient and modern individuals from South America from Western Patagonia. We found a strong affinity between modern and ancient individuals from the region, providing evidence of continuity in the region for the last ≈1,000 years

and regional genetic structure within Southern South America. In particular, the analysis of these ancient genomes helps address questions related to the maritime tradition in the region and its diversification posterior to the split from terrestrial hunter-gatherers.

Anthropologie

Isbell 2018

Lynne A. Isbell, Laura R. Bidner, Eric K. Van Cleave, Akiko Matsumoto-Oda & Margaret C. Crofoot, *GPS-identified vulnerabilities of savannah-woodland primates to leopard predation and their implications for early hominins*. Journal of Human Evolution **118** (2018), 1–13.

Predation is thought to have been a key selection pressure in primate evolution, especially in the savannah-woodland habitats where several early hominin species lived. However, predator-primate prey relationships are still poorly understood because human presence often deters predators, limiting our ability to quantify the impact of predation. Synchronized high-resolution tracking of leopards (Panthera pardus), vervets (Chlorocebus pygerythrus), and olive baboons (Papio anubis) during a 14-month study in Kenya revealed that increased vulnerability to leopard predation was not associated with higher encounter rates, smaller body size, smaller group size, or greater distance from refuges, contrary to longstanding inferences. Instead, the initiation, rate, timing, and duration of encounters, outcome of approaches, and predation events showed only a diel pattern of differential vulnerability. In the absence of human observers, vervets were more vulnerable during the day, whereas baboons were more vulnerable at night, but overall neither species was more vulnerable than the other. As our results show that leopards avoided baboons during the day and hunted them at night, we suggest that the same pattern would have applied to homininsdbecause they were even larger than baboons and bipedal, resulting in similarly offensive capability on the ground during the day but poorer agility in the trees at night, especially as they became committed bipeds. Drawing from hominid behavior and archaeopaleontological and ethnographic evidence, we hypothesize that ground-sleeping hominins initially dealt with this formidable threat by using stone tools to modify Acacia branches into 'bomas', thorny enclosures that provided nighttime shelter. The ability of hominins to create their own nightly refuges on the ground wherever Acacia spp. were available would have allowed them to range more widely, a crucial step in furthering the spread of hominins across Africa and beyond.

Keywords: Predator-prey interactions | Antipredator behavior | Cercopithecine primates | Hominin behavior

Peterson 2018

Alexandria Peterson, Elicia F. Abella, Frederick E. Grine, Mark F. Teaford & Peter S. Ungar, *Microwear textures of Australopithecus africanus and Paranthropus robustus molars in relation to paleoenvironment and diet*. Journal of Human Evolution **119** (2018), 42–63.

The importance of diet in primate ecology has motivated the use of a variety of methods to reconstruct dietary habits of extinct hominin taxa. Dental microwear is one such approach that preserves evidence from consumed food items. This study is based on 44 specimens of Australopithecus africanus from Makapansgat and

Sterkfontein, and 66 specimens of Paranthropus robustus from Swartkrans, Kromdraai and Drimolen. These samples enable examination of potential differences between the two assemblages of A. africanus, and among the various assemblages of P. robustus in relation to the paleoenvironmental reconstructions that have been proffered for each fossil site. Sixteen microwear texture variables were recorded for each specimen from digital elevation models generated using a white-light confocal profiler. Only two of these differ significantly between the Makapansgat and Sterkfontein samples of A. africanus. None of the microwear texture variables differs significantly among the samples of P. robustus. On the other hand, P. robustus has significantly higher values than A. africanus for 11 variables related to feature complexity, size, and depth; P. robustus exhibits rougher surfaces that comprise larger, deeper features. In contrast, A. africanus has smoother, simpler wear surfaces with smaller, shallower and more anisotropic features. As for possible habitat differences among the various sites, only a relatively small number of subtle differences are evident between the specimens of A. africanus from Makapansgat and Sterkfontein, and there are none among the specimens of P. robustus from various deposits. As such, it is reasonable to conclude that, while subtle differences in microwear textures may reflect differences in background habitats, the wear fabric differences between P. robustus and A. africanus are most reasonably interpreted as having been driven by dietary differences.

Keywords: Makapansgat | Sterkfontein | Swartkrans | Kromdraai | Drimolen | Confocal profilometry

Rodríguez 2018

Jesús Rodríguez & Ana Mateos, *Carrying capacity, carnivoran richness and hominin survival in Europe*. Journal of Human Evolution **118** (2018), 72–88.

Carrying capacity, the maximum biomass that an ecosystem can sustain over the long term, strongly influences several ecological processes and it is also one of the main determinants of biodiversity. Here, we estimate the carrying capacity (CC) of the late Early and early Middle Pleistocene ecosystems of Europe, using equations describing the relationship between CC and climatic variables observed in the present, as well as maps of inferred paleotemperature and paleoprecipitation. Maps of paleoclimate values were interpolated from the composite benthic stable oxygen isotope ratios and a transfer function was used to estimate ungulate carrying capacity (CCU) from the interpolated mean annual temperature and annual precipitation values. Carnivoran carrying capacity was subsequently estimated from ungulate carrying capacity and the effect of CC on the carnivoran faunas was analyzed in 12 paleocommunities from Southern Europe. Our results show that carnivoran species richness is strongly related to ungulate carrying capacity in recent ecosystems, but the late Early Pleistocene paleocommunities from Southern Europe included much richer carnivore guilds than would be expected for a recent community with a similar ungulate carrying capacity. Thus, those late Early Pleistocene ecosystems supported a high number of carnivoran species, but the carnivoran biomass they could support was relatively low. Consequently, carnivorans occurred at low densities in Southern Europe compared to the recent African savanna ecosystems, but likely also compared to coeval East African ecosystems. Consequently, the first Homo populations that arrived in Europe at the end of the late Early Pleistocene found mammal communities consisting of a low number of prey species, which accounted for a moderate herbivore biomass, as well as a diverse but not very abundant carnivore guild. This relatively low carnivoran density implies that the hominin-carnivore encounter rate was lower in the European ecosystems than in the coeval East African environments, suggesting that an op-

portunistic omnivorous hominin would have benefited from a reduced interference from the carnivore guild.

Keywords: Early Pleistocene | Homo | Hominin niche | Mammals | Carnivoran density

Biologie

ORLANDO 2013

Ludovic Orlando et al., *Recalibrating Equus evolution using the genome sequence of an early Middle Pleistocene horse.* nature **499** (2013), 74–78.

Ludovic Orlando, Aurélien Ginolhac, Guojie Zhang, Duane Froese, Anders Albrechtsen, Mathias Stiller, Mikkel Schubert, Enrico Cappellini, Bent Petersen, Ida Moltke, Philip L. F. Johnson, Matteo Fumagalli, Julia T. Vilstrup, Maanasa Raghavan, Thorfinn Korneliussen, Anna-Sapfo Malaspinas, Josef Vogt, Damian Szklarczyk, Christian D. Kelstrup, Jakob Vinther, Andrei Dolocan, Jesper Stenderup, Amhed M. V. Velazquez, James Cahill, Morten Rasmussen, Xiaoli Wang, Jiumeng Min, Grant D. Zazula, Andaine Seguin-Orlando, Cecilie Mortensen, Kim Magnussen, John F. Thompson, Jacobo Weinstock, Kristian Gregersen, Knut H. Røed, Véra Eisenmann, Carl J. Rubin, Donald C. Miller, Douglas F. Antczak, Mads F. Bertelsen, Søren Brunak, Khaled A. S. Al-Rasheid, Oliver Ryder, Leif Andersson, John Mundy, Anders Krogh, M. Thomas P. Gilbert, Kurt Kjær, Thomas Sicheritz-Ponten, Lars Juhl Jensen, Jesper V. Olsen, Michael Hofreiter, Rasmus Nielsen, Beth Shapiro, JunWang & Eske Willerslev

The rich fossil record of equids has made them a model for evolutionary processes1. Here we present a 1.12-times coverage draft genome from a horse bone recovered from permafrost dated to approximately 560–780 thousand years before present (kyr BP)2,3. Our data represent the oldest full genome sequence determined so far by almost an order of magnitude. For comparison, we sequenced the genome of a Late Pleistocene horse (43 kyr BP), and modern genomes of five domestic horse breeds (Equus ferus caballus), a Przewalski's horse (E. f. przewalskii) anda donkey (E. asinus). Our analyses suggest that the Equus lineage giving rise to all contemporary horses, zebras and donkeys originated 4.0–4.5million years before present (Myr BP), twice the conventionally accepted time to the most recent common ancestor of the genus Equus4,5. We also find that horse population size fluctuated multiple times over the past 2Myr, particularly during periods of severe climatic changes. We estimate that the Przewalski's and domestic horse populations diverged 38–72 kyr BP, and find no evidence of recent admixture between the domestic horse breeds and the Przewalski's horse investigated. This supports the contention that Przewalski's horses represent the last survivingwild horse population6. We find similar levels of genetic variation among Przewalski's and domestic populations, indicating that the former are genetically viable and worthy of conservation efforts. Wealso find evidence for continuous selection on the immune system and olfaction throughout horse evolution. Finally, we identify 29 genomic regions amonghorse breeds that deviate from neutrality and show low levels of genetic variation compared to the Przewalski's horse. Such regions could correspond to loci selected early during domestication.

URLACHER 2018

Samuel S. Urlacher et al., *Tradeoffs between immune function and childhood growth among Amazonian forager-horticulturalists.* PNAS **115** (2018), E3914–E3921.

pnas115-E03914-Supplement.pdf

Samuel S. Urlacher, Peter T. Ellison, Lawrence S. Sugiyama, Herman Pontzer, Geeta Eick, Melissa A. Liebert, Tara J. Cepon-Robins, Theresa E. Gildner & J. Josh Snodgrass

Immune function is an energetically costly physiological activity that potentially diverts calories away from less immediately essential life tasks. Among developing organisms, the allocation of energy toward immune function may lead to tradeoffs with physical growth, particularly in high-pathogen, low-resource environments. The present study tests this hypothesis across diverse timeframes, branches of immunity, and conditions of energy availability among humans. Using a prospective mixed-longitudinal design, we collected anthropometric and blood immune biomarker data from 261 Amazonian forager-horticulturalist Shuar children (age 4–11 y old). This strategy provided baseline measures of participant stature, s.c. body fat, and humoral and cell-mediated immune activity as well as subsample longitudinal measures of linear growth (1 wk, 3 mo, 20 mo) and acute inflammation. Multilevel analyses demonstrate consistent negative effects of immune function on growth, with children experiencing up to 49 % growth reduction during periods of mildly elevated immune activity. The direct energetic nature of these relationships is indicated by (i) the manifestation of biomarker-specific negative immune effects only when examining growth over timeframes capturing active competition for energetic resources, (ii) the exaggerated impact of particularly costly inflammation on growth, and (iii) the ability of children with greater levels of body fat (i.e., energy reserves) to completely avoid the growth-inhibiting effects of acute inflammation. These findings provide evidence for immunologically and temporally diverse body fat-dependent tradeoffs between immune function and growth during childhood. We discuss the implications of this work for understanding human developmental energetics and the biological mechanisms regulating variation in human ontogeny, life history, and health.

Keywords: life history theory | energetics | phenotypic plasticity | inflammation | adaptive immunity

Significance: The energetic impact of immune function on human growth remains unclear. Using data from Amazonian forager-horticulturalists, we show that diverse, low-level immune activity predicts reduced childhood growth over periods of competing energy use ranging from 1 wk to 20 mo. We also demonstrate that modest body fat stores (i.e., energy reserves) protect children from the particularly detrimental impact of acute inflammation on growth. These findings provide evidence for considerable energetic tradeoffs between immune function and growth among humans, highlighting the energy constraint of childhood and the characteristic ability of our species to respond sensitively to dynamic environmental conditions. We outline the possible role of immune-related tradeoffs in driving patterns of human growth faltering, developmental metabolic plasticity, and life history evolution.

Energie

Krekel 2018

Daniel Krekel, Remzi Can Samsun, Ralf Peters & Detlef Stolten, *The separation of CO2 from ambient air, A techno-economic assessment.* Applied Energy **218** (2018), 361–381.

This paper assesses the separation of CO2 from ambient air from a technical and economic standpoint. Reducing CO2 emissions and their sequestration from the atmosphere is vital to counteract ongoing climate change. The most promising

technological options for CO2 separation are first identified by reviewing the literature and comparing the most important technical and economic parameters. The results point to amines/imines as adsorbing agents to separate CO2 from ambient air. A system layout is then designed and a technical analysis conducted by solving mass and energy balances for each component. An economic analysis is then performed by applying a specifically-developed model. The total energy demand of the system discussed here is calculated as 3.65 GJ/tCO2. This high energy demand mainly derives from the system-specific implementation of two compressors that compress air/CO2 and overcome the pressure losses. The second-law efficiency calculated ranges of 7.52–11.83 %, depending on the option of heat integration. The costs of avoiding CO2 emissions vary between $ 824 and 1333/tCO2, depending on the energy source applied. The results of this work present higher values for energy demand and costs compared to other values stated in literature. The reasons for this deviation are often insufficient and overoptimistic assumptions in other literature on the one hand, but also relate to the specific system design investigated in this paper on the other. Further case studies reveal that enormous land requirements and investments would be needed to reduce potential CO2 quantities in the atmosphere to contemporary levels. A comparison between CO2 removal from the atmosphere and carbon capture and storage technology for coal power plants shows that this technology is not yet able to economically compete with carbon capture and storage. Furthermore, the impact of CO2 separation on the production costs of industrial commodities like cement and steel demonstrates that CO2 removal from the atmosphere is not yet a viable alternative to solving the climate change problem. In the long-term, CO2 separation from ambient air may still play an important role in the sequestration of CO2 from diluted and dispersed sources, as the technology has the potential for significant further development and optimization.

Keywords: CO2separation from the atmosphere | Techno-economic analysis | Climate change | Carbon capture and storage | CO2abatement costs | Polyethyleneimine adsorption

Judentum

Yadin 1966
Yigael Yadin, *Masada, Der letzte Kampf um die Festung des Herodes.* (Stuttgart ^{3}1967). Original: Herod's fortress and the Zealots' last stand.

Yadin 1971
Yigael Yadin, *Bar Kochba, Archäologen auf den Spuren des letzten Fürsten von Israel.* (Stuttgart 1971). Original: The rediscovery of the legendary hero. . . .

Klima

D'Anjou 2012
Robert M. D'Anjou, Raymond S. Bradley, Nicholas L. Balascio & David B. Finkelstein, *Climate impacts on human settlement and agricultural activities in northern Norway revealed through sediment biogeochemistry.* PNAS **109** (2012), 20332–20337.
pnas109-20332-Supplement.pdf

Disentangling the effects of climate change and anthropogenic activities on the environment is a major challenge in paleoenvironmental research. Here, we used fecal sterols and other biogeochemical compounds in lake sediments from northern Norway to identify both natural and anthropogenic signals of environmental change during the late Holocene. The area was first occupied by humans and their grazing animals at ≈2,250 ± 75 calendar years before 1950 AD (calendar years before present). The arrival of humans is indicated by an abrupt increase in coprostanol (and its epimer epicoprostanol) in the sediments and an associated increase in 5ß-stigmastanol (and 5ß-epistigmastanol), which resulted from human and animal feces washing into the lake. Human settlement was accompanied by an abrupt increase in landscape fires (indicated by the rise in pyrolytic polycyclic aromatic hydrocarbons) and a decline in woodland (registered by a change in n-alkane chain lengths from leaf waxes), accelerating a process that began earlier in the Holocene. Human activity and associated landscape changes in the region over the last two millennia were mainly driven by summer temperatures, as indicated by independent tree-ring reconstructions, although there were periods when socioeconomic factors played an equally important role. In this study, fecal sterols in lake sediments have been used to provide a record of human occupancy through time. This approach may be useful in many archeological studies, both to confirm the presence of humans and grazing animals, and to distinguish between anthropogenic and natural factors that have influenced the environment in the past.

Keywords: biomarkers | paleoclimate | geoarchaeology | paleolimnology

Kultur

Horejs 2016

Barbara Horejs, *Neue Gewichtssysteme und Metallurgischer Aufschwung im frühen 3. Jahrtausend, Ein Zufall?* In: Martin Bartelheim, Barbara Horejs & Raiko Krauss (Hrsg.), *Von Baden bis Troia – Ressourcennutzung, Metallurgie und Wissenstransfer, Jubiläumsschrift für Ernst Pernicka.* Oriental and European Archaeology 3 (Rahden 2016), 251–272.

Anhand von fünf erstmals präsentierten Gewichtssteinen aus den frühbronzezeitlichen Siedlungen des Çukuriçi Höyük in Westanatolien wird die Frage eines Zusammenhangs von neuen metrischen Systemen, Metallurgie und den sozialenpolitischen Rahmenbedingungen diskutiert. Die detaillierte kontextuelle Analyse der ÇukuriçiGewichte zeigt einen klaren Zusammenhang mit metallurgischen Aktivitäten. Ihre Datierung zwischen 2900 und 2750 v. Chr. belegt die rasche und dynamische Verbreitung dieser metrischen Standardisierung bis an die Ägäisküste Westanatoliens. Während die soziokulturelle Einbettung funktionierender Gewichtsstandards in den Ursprungsregionen Levante und Mesopotamien deutlich hierarchisch geprägt ist, wird für die Fallstudie an der westanatolischen Küste ein anderes Konzept diskutiert. Die homogene Siedlungsstruktur mit regelmäßiger Verteilung metallurgischer Werkstätten und das Fehlen herausgehobener Zentralbauten lässt eine breite Partizipation der Bevölkerung an diesen Aktivitäten vermuten. Die ebenfalls in verschiedenen Werkstätten oder deren unmittelbarer Umgebung gefundenen Gewichte bestätigen, dass hier keine zentrale Nutzung oder Akkumulation vorliegt. Während die Überbringer und Kenntnisträger der neuen metrischen Systeme wohl von außen kommen (Händler?), sind die Anwender der innovativen Gewichtsstandards auf dem frühbronzezeitlichen Çukuriçi Höyük zu identiizieren. Diese Gesellschaft kann als komplexe Wirtschaftsform mit Arbeitsteilung durch spezialisierte Gruppen beschrieben werden, die

entsprechende Kompetenzen ausbilden und weiterentwickeln. Daraus mag sich eine temporäre hierarchische Struktur entwickelt haben, die aber nicht in eine stabile und dauerhafte politische Hierarchisierung der Gesellschaft mündet, was als heterarchische Organisationsform deiniert werden kann. Schließlich stellen die ersten metrischen Standards einen wichtigen Faktor für soziale und ökologische Macht dar, die sich auch in Kontrolle, Gewährleistung und Akzeptanz widerspiegeln. Die Bewohner des Çukuriçi Höyük in der Frühbronzezeit 1 haben dieses innovative System für ihre wohl metallurgischen Produkte (Arsenkupfer, Silber, Gold) eingesetzt, ohne diese ökologische Macht innerhalb ihrer Gemeinschaft zu zentralisieren.

Keywords: Gewichte | Metallurgiezentrum | Heterarchie | Frühe Bronzezeit | Westanatolien | Çukuriçi Höyük

Kupfer

Powell 2017

Wayne Powell, Ryan Mathur, H. Arthur Bankoff, Andrea Mason, Aleksandar Bulatović, Vojislav Filipović & Linda Godfrey, *Digging deeper, Insights into metallurgical transitions in European prehistory through copper isotopes*. Journal of Archaeological Science **88** (2017), 37–46.

JAS088-0037-Comment1.pdf, JAS088-0037-Reply1.pdf

Southeastern Europe is the birthplace of metallurgy, with evidence of copper smelting at ca. 5000 BCE. There the later Eneolithic (Copper Age) was associated with the casting of massive copper tools. However, copper metallurgy in this region ceased, or significantly decreased, centuries before the dawn of the Bronze Age. Archaeologists continue to be debate whether this hiatus was imposed on early metalworking communities as a result of exhaustion of workable mineral resources, or instead a cultural transition that was associated with changes in depositional practices and material culture. Copper isotopes provide a broadly applicable means of addressing this question. Copper isotopes fractionate in the near-surface environment such that surficial oxide ores can be differentiated from non-weathered sulphide ores that occur at greater depth. This compositional variation is transferred to associated copper artifacts, the final product of the metallurgical process. In the central Balkans, a shift from 65Cu-enriched to 65Cu-depleted copper artifacts occurs across the metallurgical hiatus at the Eneolithic-Bronze Age boundary, ca. 2500 BCE. This indicates that the reemergence of metal production at the beginning of the Bronze Age is associated with pyrotechnical advancements that allowed for the extraction of copper from sulphide ore. Thus copper isotopes provide direct evidence that the copper hiatus was the result of exhaustion of near-surface oxide ores after one-and-a-half millennia of mining, and that the beginning of the Bronze Age in the Balkans is associated with the introduction of more complex smelting techniques for metal extraction from regionally abundant sulphidic deposits.

Keywords: Bronze age | Eneolithic | Serbia | Balkans | Copper | Isotopes | Metallurgy

Methoden

Allentoft 2012

Morten E. Allentoft et al., *The half-life of DNA in bone, Measuring decay kinetics in 158 dated fossils*. Proc. Royal Society B **279** (2012), 4724–4733.

Morten E. Allentoft, Matthew Collins, David Harker, James Haile, Charlotte L. Oskam, Marie L. Hale, Paula F. Campos, Jose A. Samaniego, M. Thomas P. Gilbert, Eske Willerslev, Guojie Zhang, R. Paul Scofield, Richard N. Holdaway & Michael Bunce

Claims of extreme survival of DNA have emphasized the need for reliable models of DNA degradation through time. By analysing mitochondrial DNA (mtDNA) from 158 radiocarbon-dated bones of the extinct New Zealand moa, we confirm empirically a long-hypothesized exponential decay relationship. The average DNA half-life within this geographically constrained fossil assemblage was estimated to be 521 years for a 242 bp mtDNA sequence, corresponding to a per nucleotide fragmentation rate (k) of 5.50 . 10–6 per year. With an effective burial temperature of 13.18C, the rate is almost 400 times slower than predicted from published kinetic data of in vitro DNA depurination at pH 5. Although best described by an exponential model (R2 = 0.39), considerable sample-to-sample variance in DNA preservation could not be accounted for by geologic age. This variation likely derives from differences in taphonomy and bone diagenesis, which have confounded previous, less spatially constrained attempts to study DNA decay kinetics. Lastly, by calculating DNA fragmentation rates on Illumina HiSeq data, we show that nuclear DNA has degraded at least twice as fast as mtDNA. These results provide a baseline for predicting long-term DNA survival in bone.

Keywords: DNA degradation | aDNA | decay kinetics | DNA half-life

Berstan 2008

R. Berstan, A. W. Stott, S. Minnitt, C. Bronk Ramsey, R. E. M. Hedges & R. P. Evershed, *Direct dating of pottery from its organic residues, New precision using compound-specific carbon isotopes*. Antiquity **82** (2008), 702–713.

Techniques for identifying organic residues in pottery have been refined over the years by Professor Evershed and his colleagues. Here they address the problem of radiocarbon dating these residues by accelerator mass spectrometry (AMS) which in turn dates the use of the pot. Fatty acids from carcass and dairy products cooked in the pot were isolated from early Neolithic carinated bowls found at the Sweet Track, Somerset Levels, England, and then dated by AMS. The results were very consistent and gave an excellent match to the dendrochronological date of the trackway. The method has wide potential for the precise dating of pottery use on sites.

Keywords: England | Somerset Levels | Neolithic | pottery | organic residues | fatty acids | radiocarbon | dendrochronology

Buckley 2004

Stephen A. Buckley, Katherine A. Clark & Richard P. Evershed, *Complex organic chemical balms of Pharaonic animal mummies*. nature **431** (2004), 294–299.

Millions of votive mummies of mammals, birds and reptiles were produced throughout ancient Egypt, with their popularity increasing during the reign of Amenhotep III (1400 BC) and thereafter. The scale of production has been taken to indicate that relatively little care and expense was involved in their preparation compared with human mummies1–3. The accepted view is that animals were merely wrapped in coarse linen bandages and/or dipped in 'resin' before death2–4. However, as with human mummification there was a range of qualities of treatments, and visual inspection of animal mummies suggests that the procedures used were often as complex as those used in humans (for example, evisceration and

elaborate bandaging). Moreover, the ancient Egyptians treated animals with great respect, regarding them both as domestic pets and representatives of the gods; for example, the cat symbolized the goddess Bastet; the hawk, Horus; the ibis, Thoth, and so on. We report here the results of chemical investigations of tissues and wrappings from Pharaonic cat, hawk and ibis mummies using gas chromatography, gas chromatography–mass spectrometry, thermal desorption–gas chromatography–mass spectrometry and pyrolysis–gas chromatography–mass spectrometry5,6. The analyses reveal the presence of highly complex mixtures of n-alkyl and cyclic biomarker components characteristic of fats, oils, beeswax, sugar gum, petroleum bitumen, and coniferous, Pistacia and possibly cedar resins. The mixture of balms is of comparable complexity to those used to mummify humans from the same period6–8.

Bull 2001

Ian D. Bull, Phillip P. Betancourt & Richard P. Evershed, *An Organic Geochemical Investigation of the Practice of Manuring at a Minoan Site on Pseira Island, Crete*. Geoarchaeology **16** (2001), 223–242.

Lipid components in a soil profile developed in an agricultural terrace at a Minoan site on Pseira Island, Crete, were analyzed to determine whether the practice of manuring in antiquity, as inferred by distributional and temporal sherd scatter, could be confirmed through the use of biomarker compounds as proxies for manuring. Analysis of total organic carbon and the abundance of n-alkyl lipids (n-alkanols and fatty acids) demonstrated that while the upper part of the soil profile had received more recent inputs of vegetation-derived organic matter, the deeper archaeological strata remained essentially undisturbed. Further analysis of 5b-stanols, sterol components which may be utilized as fecal biomarkers, revealed a signal indicative of manuring, with human or porcine-derived fecal material, in the lower 15 cm of the profile. Additional appraisal of epicoprostanol abundance inferred the possible practice of composting in later periods. This study represents a detection of manuring, in the oldest samples to date, using organic geochemical methods.

Clark 2013

Katherine A. Clark, Salima Ikram & Richard P. Evershed, *Organic chemistry of balms used in the preparation of pharaonic meat mummies*. PNAS **110** (2013), 20392–20395.

The funeral preparations for ancient Egyptian dead were extensive. Tomb walls were often elaborately painted and inscribed with scenes and objects deemed desirable for the afterlife. Votive objects, furniture, clothing, jewelry, and importantly, food including bread, cereals, fruit, jars of wine, beer, oil, meat, and poultry were included in the burial goods. An intriguing feature of the meat and poultry produced for the deceased from the highest levels of Egyptian society was that they were mummified to ensure their preservation. However, little is known about the way they were prepared, such as whether balms were used, and if they were used, how they compared with those applied to human and animal mummies? We present herein the results of lipid biomarker and stable carbon isotope investigations of tissues, bandaging, and organic balms associated with a variety of meat mummies that reveal that treatments ranged from simple desiccation and wrapping in bandages to, in the case of the tomb of Yuya and Tjuia (18th Dynasty, 1386–1349 BC), a balm associated with a beef rib mummy containing a high abundance of Pistacia resin and, thus, more sophisticated than the balms found on many contemporaneous human mummies.

Keywords: food mummies | pharaohs | Egypt | triterpenoids | fatty acyl lipids

Significance

This unique research on the chemical composition of organic balms of food mummies completes the trilogy of mummy types known from Ancient Egypt, complementing previous investigations of human and animal mummies. Our findings show that the Ancient Egyptians prepared the food offerings they made to their dead using preservation techniques at least as exotic as those used in embalming human and animal mummies. The discovery of the precious Pistacia resin on a beef rib mummy is especially noteworthy because the use of this substance is rare even in human mummies.

Correa-Ascencio 2014

Marisol Correa-Ascencio & Richard P. Evershed, *High throughput screening of organic residues in archaeological potsherds using direct acidified methanol extraction*. Analytical Methods **6** (2014), 1330–1340.

Despite the significant achievements of organic residues analysis of archaeological pottery, the sometimes low lipid recovery and the need to process increasingly large collections of sherds to tackle important archaeological questions require the development of a more efficient and rapid extraction method. In this paper we present a novel methodology for the extraction of absorbed organic residues directly from crushed archaeological ceramic using acidified methanol (H2SO4–MeOH 2 % v/v, 70 ãC, 1h). This new protocol was tested by: (i) verifying the recovery of organic residues from previously studied archaeological vessels from different geographical regions, exhibiting a range of different lipid distributions often found in archaeological pottery, and (ii) demonstrating enhanced recovery of organic residues from potsherds that did not yield appreciable lipids when using the widely applied chloroform– methanol extraction. The application of the direct acidified methanol extraction recovers higher concentrations of lipid residues together with simultaneous production of methyl esters of fatty acids, allowing extraction and methylation to be completed in 20 % of the time compared to conventional solvent extraction and derivatisation for gas chromatography (GC), gas chromatography mass spectrometry (GC-MS) and gas chromatography combustion isotope ratio mass spectrometry (GC-C-IRMS).

Courel 2017

Blandine Courel et al., *Molecular, isotopic and radiocarbon evidence for broomcorn millet cropping in Northeast France since the Bronze Age*. Organic Geochemistry **110** (2017), 13–24.

Blandine Courel, Philippe Schaeffer, Pierre Adam, Estelle Motsch, Quentin Ebert, Emile Moser, Clement Feliu, Stefano M. Bernasconi, Irka Hajdas, Damien Ertlen & Dominique Schwartz

Molecular and isotopic investigation of lipids from soils filling several structures from an archaeological site located at Obernai (Alsace, NE France) has revealed the presence of miliacin, a triterpenoid marker from Panicum miliaceum (broomcorn millet), indicating that this cereal was cultivated at the site. The concentration profiles of miliacin within silos and its detection in other archaeological structures (e.g., Gaulish pit) suggest that miliacin did not originate from cereals stored in the silos but rather came from remains of millet from cultivated soils which filled the silos after they were abandoned. Furthermore, the 14C age of miliacin isolated from a silo of the Second Iron Age was shown to be considerably older (Bronze Age) than the structure itself, revealing that the soil filling the silo therefore archived the molecular signature from past millet cropping, predating the digging of the silo. Thus, radiocarbon dating of the isolated miliacin allowed the timing of millet cropping to be determined, showing that it was established

during the Bronze Age and the Roman Gaul period at Obernai. This is the first evidence of millet cultivation in Alsace dating back to the Bronze Age, bringing new perspectives on agricultural practices and past dietary practice in Eastern France. The combination of molecular studies and radiocarbon dating of individual lipids highlights the potential of hollow structures like silos and pits to act as "pedological traps", recording information on past vegetation cover or agricultural practices from the surface horizons of surrounding soils that filled these structures after abandonment.

Keywords: Soil lipids | Panicum miliaceum | Miliacin | Compound-specific radiocarbon analysis | Pedological traps | Archaeometry

Evershed 2002

Richard P. Evershed et al., *Chemistry of Archaeological Animal Fats.* Accounts Chemical Research **35** (2002), 660–668.

Richard P. Evershed, Stephanie N. Dudd, Mark S. Copley, Robert Berstan, Andrew W. Stott, Hazel Mottram, Stephen A. Buckley & Zoe Crossman

Animal fats are preserved at archaeological sites in association with unglazed pottery, human and animal remains, and other deposits or hoards. High-temperature gas chromatography (HT-GC) and combined HT-GC/mass spectrometry (HT-GC/MS) has confirmed the presence of animal fats in lipid extracts of artifacts. Degradation products and pathways have been discerned through the analyses of archaeological finds and the products of laboratory and fieldbased decay experiments. The origins of preserved fats have been determined through detailed compositional analysis of their component fatty acids by GC, by GC/MS of dimethyl disulfide derivatives of monoenoic components, and by GC-combustion-isotope ratio-MS (GC-C-IRMS), to derive diagenetically robust d13C values. Regiospecific analysis of intact triacylglycerols by high-performance liquid chromatography/MS (HPLC/MS), with atmospheric pressure chemical ionization, provides a further criterion for establishing the origin of fats. Preparative GC has been employed to isolate individual fatty acids from archaeological pottery in sufficient amounts for 14C dating.

Evershed 2004

R. P. Evershed, R. Berstan, F.Grew, M. S. Copley, A. J. H. Charmant, E. Barham, H. R.Mottram & G. Brown, *Formulation of a Roman cosmetic.* nature **432** (2004), 35–36.

This unguent shares some surprising features with modern moisturizing creams.

Gill 2010

Fiona L. Gill et al., *Archaeol – a biomarker for foregut fermentation in modern and ancient herbivorous mammals?* Organic Geochemistry **41** (2010), 467–472.

Fiona L. Gill, Richard J. Dewhurst, Jennifer A. J. Dungait, Richard P. Evershed, Luke Ives, Cheng-Sen Li, Richard D. Pancost, Martin Sullivan, Subir Bera & Ian D. Bull

A pilot study was conducted to investigate the hydroxylated lipid content of faeces from a range of herbivorous animals with either foregut or hindgut fermenting digestive systems. Assessment of the sterol distributions derived from the faeces revealed that, whilst there were differences in the relative concentrations of individual compounds between species, there was no overall characteristic that could be used to differentiate between foregut and hindgut fermenters. However, the concentration of archaeol in each of the modern faeces varied between 5 and 49 ug/g

dry wt for the foregut fermenters, whilst archaeol was not detected in faeces from hindgut fermenters. Based on these results, it is proposed that archaeol might be a useful proxy for methanogenesis in foregut fermenting digestive systems and, further, that the presence of archaeol may be used to infer a foregut digestive origin for coprolites from ancient herbivores. Consistent with this proposal, analysis of a sub-fossil ovi-caprid coprolite yielded detectable quantities of archaeol.

Hofreiter 2012

Michael Hofreiter, Matthew Collins & John R. Stewart, *Ancient biomolecules in Quaternary palaeoecology*. Quaternary Science Reviews **33** (2012), 1–13.

The last few years have seen an enormous proliferation of ancient biomolecules research, especially in the field of ancient DNA. Ancient DNA studies have been transformed by the advent of next generation sequencing, with the first Pleistocene sample being analysed in 2005, and several complete and draft genomes that have been compiled from ancient DNA to date. At the same time, although less conspicuous, research on ancient proteins has also seen advances, with the time limit for research on ancient biomolecules now extending to over 1 million years. Here we review which effects these developments have on research in Quaternary science. We identify several lines of research that have the potential to profit substantially from these recent developments in ancient biomolecules research. First, the identification of taxa can be made using ancient biomolecules, and in the case of ancient DNA, specimens can even be assigned to specific populations within a species. Second, increasingly large DNA data sets from Pleistocene animals allow the elucidation of ever more precise pictures of the population dynamic processes whereby organisms respond to climate and environmental change. With the accompanying better understanding of process in the Quaternary, past ecologies can also more realistically be interpreted from proxy data sets. The dominant message from this research so far is that the Quaternary saw a great deal more dynamism in populations than had been forecast by conventional palaeoecology. This suggests that reconstructions of past environmental conditions need to be done with caution. Third, ancient DNA can also now be obtained directly from sediments to elucidate the presence of both plant and animal species in an area even in the absence of identifiable fossils, be it macro- or micro-fossils. Finally, the analysis of proteins enables the identification of bone remains to genus and sometimes species level far beyond the survival time of DNA, at least in temperate regions, illustrating that precise data is now forthcoming from seemingly unlikely sources. Together, these approaches allow the study of environmental dynamics throughout a substantial part, and perhaps even the entire Quaternary (the last 2.6 million years).

Keywords: Ancient DNA | Ancient biomolecules | Ancient proteins | Collagen | Quaternary palaeoecology | Pleistocene | Population dynamics | Taxonomic identification

Itahashi 2018

Yu Itahashi, Akira Tsuneki, Sean P. Dougherty, Yoshito Chikaraishi, Naohiko Ohkouchi & Minoru Yoneda, *Dining together: Reconstruction of Neolithic food consumption based on the $\delta^{15}N$ values for individual amino acids at Tell el-Kerkh, northern Levant*. Journal of Archaeological Science: Reports **17** (2018), 775–784.

We report here stable nitrogen isotope values of amino acids and stable carbon and nitrogen isotope values of collagen in human (n=18) and faunal remains from Tell el-Kerkh, which was a large settlement in the northern Levant during

the Neolithic period. A unique outdoor communal cemetery involving> 240 individual burials was found in the Pottery Neolithic levels at Tell el-Kerkh. To test the hypothesis that the burial locations of individuals within the cemetery were determined by household units sharing food resources, we separated individuals from one layer into seven groups within the cemetery, and compared the isotope values of collagen, glutamic acid, and phenylalanine. The results of analysis of individual skeletons in the cemetery suggest that the early farmers had different isotope values based on their burial locations, perhaps indicating distinct household burial spaces.

Keywords: Paleodiet | Isotopes | Amino acids | Neolithic | Near east | Household | Food sharing

James 2009

Matthew A. James et al., *High prestige Royal Purple dyed textiles from the Bronze Age royal tomb at Qatna, Syria*. Antiquity **83** (2009), 1109–1118.

Matthew A. James, Nicole Reifarth, Anna J. Mukherjee, Matthew P. Crump, Paul J. Gates, Peter Sandor, Francesca Robertson, Peter Pf¡§alzner & Richard P. Evershed

During the ongoing excavations in the palace of the famous Qatna complex, the excavators noted patches of brown staining on the floor of a high status tomb. Chemical extraction revealed the presence of brominated derivatives of indigo and indirubin, and more detailed characterisation showed that it likely came from Hexaplex trunculus. In short, this was none other than the renowned Tyrian or Royal Purple mentioned by Pliny, which was to have such an influential career colouring the clothing of the powerful. Furthermore, it was associated in the tomb with ghosts of high quality textiles preserved in gypsum.

Keywords: Qatna | Syria | royal tomb | sediments | biomarkers | indigoids | indirubinoids | shellfish purple | textiles | gypsum | chemical mapping | excavation technique

Lucquin 2016

Alexandre Lucquin, Andre C. Colonese, Thomas F. G. Farrell & Oliver E. Craig, *Utilising phytanic acid diastereomers for the characterisation of archaeological lipid residues in pottery samples*. Tetrahedron Letters **57** (2016), 703–707.

Phytanic acid diastereomers, 3S,7R,11R,15-phytanic acid (SRR) and 3R,7R,11R,15-phytanic acid (RRR), were determined by GC–MS in extracts of archaeological ceramic. The SRR % was higher in pottery from coastal sites corresponding with 13C enriched n-alkanoic acid corroborating a predominantly marine origin for the food residues. Conversely, low SRR % and 13C depleted n-alkanoic acid were found at inland sites, which are most likely derived from ruminant products. These observations are explained by differences in the bacterial transformation of phytol to phytanic acid between ruminant and aquatic organisms and allow these products to be easily distinguished in archaeological contexts.

Keywords: Phytanic acid | Diastereomer | GC-c-IRMS | Biomarker | Archaeology | Residue analysis

Marlar 2000

Richard A. Marlar, Banks L. Leonard, Brian R. Billman, Patricia M. Lambert & Jennifer E. Marlar, *Biochemical evidence of cannibalism*

at a prehistoric Puebloan site in southwestern Colorado. nature **407** (2000), 74–78.

The existence of cannibalism is one of the most controversial issues in the archaeology of the American Southwest. Disarticulated, cut-marked and heat-altered human remains from nonburial contexts at prehistoric Puebloan (Anasazi) archaeological sites in the Four Corners region of the American Southwest have been interpreted by some scholars as evidence of cannibalism. Osteological studies indicate that many of the disarticulated bodies found at these sites were processed in a manner consistent with food preparation2. Opponents of this interpretation point out that non-cannibalistic practices such as secondary interment, corpse mutilation and ritualized witch executions might account for the assemblages3–7. Osteological evidence alone does not document the actual ingestion of human flesh. Here we show consumption of human flesh did occur as demonstrated in preserved human waste containing identifiable human tissue remains from a site with osteological evidence of cannibalism.

Pedersen 2015

Mikkel Winther Pedersen et al., *Ancient and modern environmental DNA*. Phil. Trans. Royal Society B **370** (2015), 20130383.

Mikkel Winther Pedersen, Søren Overballe-Petersen, Luca Ermini, Clio Der Sarkissian, James Haile, Micaela Hellstrom, Johan Spens, Philip Francis Thomsen, Kristine Bohmann, Enrico Cappellini, Ida Bærholm Schnell, Nathan A. Wales, Christian Carøe, Paula F. Campos, Astrid M. Z. Schmidt, M. Thomas P. Gilbert, Anders J. Hansen, Ludovic Orlando & Eske Willerslev

DNA obtained from environmental samples such as sediments, ice or water (environmental DNA, eDNA), represents an important source of information on past and present biodiversity. It has revealed an ancient forest in Greenland, extended by several thousand years the survival dates for mainland woolly mammoth in Alaska, and pushed back the dates for spruce survival in Scandinavian ice-free refugia during the last glaciation. More recently, eDNA was used to uncover the past 50 000 years of vegetation history in the Arctic, revealing massive vegetation turnover at the Pleistocene/Holocene transition, with implications for the extinction of megafauna. Furthermore, eDNA can reflect the biodiversity of extant flora and fauna, both qualitatively and quantitatively, allowing detection of rare species. As such, trace studies of plant and vertebrate DNAin the environment have revolutionized our knowledge of biogeography. However, the approach remains marred by biases related toDNAbehaviour in environmental settings, incomplete reference databases and false positive results due to contamination. We provide a review of the field.

Keywords: environmental DNA | ancient | environment | ancient DNA | review

Regert 2003

Martine Regert, Nicolas Garnier, Oreste Decavallas, Cécile Cren-Olivé & Christian Rolando, *Structural characterization of lipid constituents from natural substances preserved in archaeological environments*. Measurement Science Technology **14** (2003), 1620–1630.

The development of a research field at the border between analytical chemistry and archaeology, namely biomolecular archaeology, provides new methods for the study of organic remains highly sensitive to natural decay. Using infrared spectroscopy, gas chromatography and mass spectrometry, it is now possible to chemically identify a series of natural substances preserved in archaeological environments. This paper details the amorphous organic residues discovered in ancient pottery

or adhering to flint tools and presents an overview of the analytical methodology developed in our laboratories for the characterization of such remains. Various natural products could be identified, such as animal or plant fats, beeswax or birch bark tar, this latter substance being an adhesive made by a controlled heating of white birch bark.

Keywords: analytical chemistry | gas chromatography | mass spectrometry | electrospray | archaeology | organic matter | beeswax | animal fat | plant oil | birch bark tar

Stott 2001

A. W. Stott, R. Berstan, P. Evershed, R. E. M. Hedges, C. Bronk Ramsey & M. J. Humm, *Radiocarbon Dating of Single Compounds Isolated from Pottery Cooking Vessel Residues*. Radiocarbon **43** (2001), 191–197.

We have developed and demonstrated a practical methodology for dating specific compounds (and octadecanoic or stearic acid—C18:0—in particular) from the lipid material surviving in archaeological cooking pots. Such compounds may be extracted from about 10 g of cooking potsherd, and, after derivatization, can be purified by gas chromatography. To obtain sufficient material for precise dating repetitive, accumulating, GC separation is necessary. Throughout the 6000-year period studied, and over a variety of site environments within England, dates on C18:0 show no apparent systematic error, but do have a greater variability than can be explained by the errors due to the separation chemistry and measurement process alone. This variability is as yet unexplained. Dates on C16:0 show greater variability and a systematic error of approximately 100–150 years too young, and it is possible that this is due to contamination from the burial environment. Further work should clarify this.

Warinner 2014

C. Warinner et al., *Direct evidence of milk consumption from ancient human dental calculus*. Scientific Reports **4** (2014), 7104. DOI:10.1038/srep07104.

C. Warinner, J. Hendy, C. Speller, E. Cappellini, R. Fischer, C. Trachsel, J. Arneborg, N. Lynnerup, O. E. Craig, D. M. Swallow, A. Fotakis, R. J. Christensen, J. V. Olsen, A. Liebert, N. Montalva, S. Fiddyment, S. Charlton, M. Mackie, A. Canci, A. Bouwman, F. Rühli, M. T. P. Gilbert & M. J. Collins

Milk is a major food of global economic importance, and its consumption is regarded as a classic example of gene-culture evolution. Humans have exploited animal milk as a food resource for at least 8500 years, but the origins, spread, and scale of dairying remain poorly understood. Indirect lines of evidence, such as lipid isotopic ratios of pottery residues, faunal mortality profiles, and lactase persistence allele frequencies, provide a partial picture of this process; however, in order to understand how, where, and when humans consumed milk products, it is necessary to link evidence of consumption directly to individuals and their dairy livestock. Here we report the first direct evidence of milk consumption, the whey protein b-lactoglobulin (BLG), preserved in human dental calculus from the Bronze Age (ca. 3000 BCE) to the present day. Using protein tandem mass spectrometry, we demonstrate that BLG is a species-specific biomarker of dairy consumption, and we identify individuals consuming cattle, sheep, and goat milk products in the archaeological record. We then apply this method to human dental calculus from Greenland's medieval Norse colonies, and report a decline of this biomarker leading up to the abandonment of the Norse Greenland colonies in the 15th century CE.

Webb 2018

Emily C. Webb et al., *Compound-specific amino acid isotopic proxies for distinguishing between terrestrial and aquatic resource consumption.* Archaeological and Anthropological Sciences **10** (2018), 1–18.

Emily C. Webb, Noah V. Honch, Philip J. H. Dunn, Anna Linderholm, Gunilla Eriksson, Kerstin Lidén & Richard P. Evershed

Abstract Compound-specific amino acid carbon-isotope compositions have shown particular promise for elucidating dietary behaviors in complex environmental contexts, and may also be able to mitigate the effect of many of the limitations inherent to palaeodietary reconstructions. Here, we investigate the efficacy of compound-specific amino acid isotopic proxies in characterizing the consumption of different dietary protein sources using amino acid carbon-isotope compositions for humans and fauna from Rössberga (Early to Middle Neolithic), Köpingsvik (Mesolithic and Middle Neolithic), and Visby (Medieval Period), Sweden. We also assess the explanatory capabilities of an isotopic mixing model when used with essential amino acid carbon-isotope compositions of humans and local fauna. All three isotopic proxies distinguished among humans from the three sites consistently and informatively, and were able to enhance the broad interpretations made using bulk isotopic compositions. The mixing model palaeodietary reconstruction revealed considerable diversity in relative protein source contributions among individuals at both Köpingsvik and Visby. Comparing the mixing model for bulk carbon- and nitrogen-isotope compositions to the model for essential amino acid isotopic compositions further demonstrated the likelihood of underestimation and overestimation of marine protein consumption for both aquatic-dominant and mixed marine-terrestrial diets when using bulk isotopic compositions.

Keywords: Amino acids | Carbon isotopes | Neolithic | Palaeodiet | Mixing models | Sweden

Mittelpaläolithikum

Power 2018

Robert C. Power et al., *Dental calculus indicates widespread plant use within the stable Neanderthal dietary niche.* Journal of Human Evolution **119** (2018), 27–41.

Robert C. Power, Domingo C. Salazar-García, Mauro Rubini, Andrea Darlas, Katerina Harvati, Michael Walker, Jean-Jacques Hublin & Amanda G. Henry

The ecology of Neanderthals is a pressing question in the study of hominin evolution. Diet appears to have played a prominent role in their adaptation to Eurasia. Based on isotope and zooarchaeological studies, Neanderthal diet has been reconstructed as heavily meat-based and generally similar across different environments. This image persists, despite recent studies suggesting more plant use and more variation. However, we have only a fragmentary picture of their dietary ecology, and how it may have varied among habitats, because we lack broad and environmentally representative information about their use of plants and other foods. To address the problem, we examined the plant microremains in Neanderthal dental calculus from five archaeological sites representing a variety of environments from the northern Balkans, and the western, central and eastern Mediterranean. The recovered microremains revealed the consumption of a variety of non-animal foods, including starchy plants. Using a modeling approach, we explored the relationships among microremains and environment, while controlling for chronology. In the process, we compared the effectiveness of various diversity metrics and their shortcomings for studying microbotanical remains, which are often morphologically

redundant for identification. We developed Minimum Botanical Units as a new way of estimating how many plant types or parts are present in a microbotanical sample. In contrast to some previous work, we found no evidence that plant use is confined to the southern-most areas of Neanderthal distribution. Although interpreting the ecogeographic variation is limited by the incomplete preservation of dietary microremains, it is clear that plant exploitation was a widespread and deeply rooted Neanderthal subsistence strategy, even if they were predominately game hunters. Given the limited dietary variation across Neanderthal range in time and space in both plant and animal food exploitation, we argue that vegetal consumption was a feature of a generally static dietary niche.

Keywords: Neanderthal diet | Dental calculus | Starches | Phytoliths | Paleodiet

Religion

Friedman 1995

Richard Elliott Friedman, *The Disappearance of God, A divine mystery.* (Boston 1995).

Zündung

Li 2018

Yuqiang Li, Yong Chen, Gang Wu & Jiangwei Liu, *Experimental evaluation of water-containing isopropanol-n-butanol-ethanol and gasoline blend as a fuel candidate in spark-ignition engine.* Applied Energy **219** (2018), 42–52.

Bio-n-butanol has attracted great attention as a potential alternative fuel in internal combustion engines (ICEs) due to its favorable physicochemical properties. However, the main issue impeding the use of bio-butanol in ICEs is its relatively high cost and energy consumption of dehydration and recovery processes in acetone-n-butanolethanol (ABE) or isopropanol-n-butanol-ethanol (IBE) fermentation technologies. Some researchers have proposed to use intermediate fermentation product, i.e. water-containing ABE or IBE, for clean combustion. Therefore, an experimental evaluation of spark-ignition (SI) engine fueled with water-containing IBE-gasoline blends was carried out in this study. Effects of IBE and water addition on combustion, performance, and emissions characteristics were first investigated at stoichiometric condition. Then, a "drop-in" fuel test was performed, i.e. IBE9W1 (9 vol. % IBE, 1 vol. % water and 90 vol. % gasoline) was compared with pure gasoline under various engine loads (3 and 5 bar BMEP) and equivalence ratios (F=0.83–1.25). It was found that IBE9W1 showed a higher brake thermal efficiency, and a lower CO, NOx and BTX (benzene, toluene and xylene) emissions. The results indicate that water-containing IBE could be used as a fuel candidate in SI engine due to its eco-friendly production method and potential to improve energy efficiency and reduce emission pollutants.

Keywords: Water-containing IBE | Performance | Combustion | Emissions | SI engine