# Death on the Nile: Why did Nilotic Later Stone Age Hunters Wage War or Keep Peace?

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Skeletons in terminal Pleistocene Later Stone Age (LSA) cemeteries (Crevecouer et al. 2021) on the Nile in northern Sudan bear many perimortem traumatic injuries, healed fractures, and embedded stone artifacts, suggesting chronic intergroup warfare. The Nile Valley was abandoned during the Younger Dryas (YD) arid phase from 12.8–11.6 ka. When the African Humid Period (AHP) resumed, the Nile was occupied by hunter-gatherer-fisher communities of the Early Khartoum tradition, 10.7–7 ka. Evidence for interpersonal violence is rare in Early Khartoum sites. However, a skeleton excavated by the Charles University (Prague) expedition at Jebel Sabaloka on the 6th Nile Cataract has a perimortem injury with a bone weapon, evinced by a snapped fragment of burned bone wedged between its ribs and scapula (Bruker Havelkova et al. 2023). Our search for answers to the question of why warfare was chronic before the Younger Dryas (YD) but rare thereafter, despite similar ecological conditions, begins with Raymond Dart's and Robert Ardrey's atavistic theories of hunting, violence, and territoriality inherited from our bone tool and weapon-wielding australopithecine ancestors. Contrasting territorial and intergroup relations among bonobos and chimpanzees in similar ecosystems obviates the instinctive killer ape and male coalition hypotheses for modern human territoriality and warfare. Comparative ethnography of warfare prevalence among hunter-gatherers (Kang 1979) suggests alternative hypotheses for modern human intergroup relationships. Patrilocal post-marital residence (PMR) is usually associated with intergroup warfare by intra-group coalitions of related males. Conversely, matrilocal PMR is frequently associated with peaceful, inter-group kinship relationships. Hypotheses of differences in PMR for contrasting patterns of Nilotic violence pre- and post-YD cannot be tested with ancient DNA but may be testable with morphometric and geochemical analyses. Innovations in modern human kinship systems may have played an important role in the diversity in modern human social and territorial organization, intra- *versus* inter-group cooperation, and warfare.

**Acknowledgements:** We thank the National Corporation for Antiquities and Museums of Sudan for authorizations and support of research on Jebel Sabaloka West Bank, the Czech Science Foundation for their long-term support of the Communities and Resources in Late Prehistory of Jebel Sabaloka, Central Sudan (GAČR 17-03207S), the Ministry of Culture of the Czech Republic (DKRVO 2019–2023/7.II.d-e, National Museum, 00023272), the Faculty of Arts of Charles University, the project "Big Dry" of the French Agence Nationale de la Recherche (ANR-14-CE31), and the International Research Project (IRP) ABASC (2020–2024) founded by the CNRS-INEE and the University of Bordeaux's IdEx "Investments for the Future" Programme/GPR "Human Past.

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# The Reverse Engineering Approach: A Pioneering Technique in the Reconstruction of Missing Anatomical Data. Preliminary Results Using Primate Femora

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The fragmentary nature of the fossil record poses a significant challenge for paleoanthropologists. While existing reconstruction techniques address some issues associated with studying fragmented hominin remains, they often rely on the presence of symmetric structures or the utilization of modern specimens or single fossil individuals as references. To overcome these challenges, we present a novel approach for reconstructing primate long bones. Our technique integrates 3D geometric morphometrics with advanced computational, mathematical, and artificially intelligent tools. Specifically, we employ what we have called the 'Reverse Engineering' method, incorporating various regression algorithms and introducing Meta-Learning approaches. This method leverages landmark-based information to predict the morphology of entire bones from fragmented portions. Using a combination of landmarks and semilandmarks, we have constructed a database characterizing the morphological variability among anatomically modern humans, chimpanzees, gorillas, orangutans, and cercopithecines. Preliminary results from the reconstruction of fragmentary femora within these groups suggest that our method yields more accurate results compared to previously developed techniques also aimed to predict missing bone portions based on landmark estimation. Our approach holds particular promise for its potential application in the hominin fossil record, as it

provides a more generalizable and accurate technique for reconstructing entire elements from even small fragments, while being also much less susceptible to issues regarding the substantial data requirements typically associated with AI-based methods.

**Acknowledgements:** JA is supported by a British Academy Newton International Fellowship (grant number: NIF22\220310). We would like to thank the NMNH of the Smithsonian Institution and the AMNH Mammalogy project for providing free access to great ape long bone 3D meshes. We are also deeply grateful to MorphoSource, the Digital Morphology Museum KUPRI, and the NMDID for providing the web support to make the files available.

## Deciphering Information Transfer Through Oldowan Tool Refits

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Humans possess a unique capacity for adaptation across a myriad of environmental landscapes, setting us apart from other nonhuman primate species. This exceptional adaptive flexibility is attributed to various factors, such as our reliance on technology, expanded dietary habits, large brain size, and the central role of social learning through imitation. While primate behavioral studies suggest the presence of a certain level of information transfer presumed to be integral to social learning, it is substantially different from the level of imitation seen in humans. Recent studies underscore the contribution of social learning to our species' success in navigating varied environmental challenges and subsequently ensuring reproductive success. Despite the acknowledged significance of social learning, understanding its origin presents a considerable challenge. Methodological difficulties persist as we try to reconstruct its evolutionary history through the limited window of a time averaged and limited archaeological record. A major challenge is that archeological assemblages likely reflect the behaviors of hundreds of likely unrelated individuals, making any understanding of variation in individual behaviors difficult. Refitted sets of stone tools, because they potentially represent individual instances of tool production, provide a unique insight into artifact production. Previously archaeologists have highlighted the decrease in variation associated with increases in information transfer. Here we explore the variation (standard deviation and variance) within technological variables (e.g., external platform angle) in refits to identify changes in behaviors over a million-year time span. Our investigation focused on the analysis of refits from six Oldowan localities spanning the first million years of this industry. We identify patterns in variation within refits suggesting diachronic changes in information transfer across this time frame. This suggests shifts in the way in which Oldowan technology was transferred between individuals. Specific variables associated with technological decisions provide insight into the ways in which hominins understood fracture mechanics.

**Acknowledgements:** This work was funded by the National Science Foundation (NSF REU #1852406; NSF CNH2-S #1924322), National Geographic (EC-73249R-21), Paleontological Scientific Trust, and the Leakey Foundation.

## Thinking Beyond the Rift: How Important is Sampling Bias in Understanding Human Evolution?

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The Eastern African Rift System preserves a large proportion of the early hominin fossil record, but it covers less than 2% of the continent. We use extant comparative models to investigate how potential biases introduced by this mismatch might affect habitat reconstruction and taxonomy. First, how would our understanding of rift-dwelling extant mammal habitats differ if all we knew about was their occurrence within the rift? Using mammal range maps from IUCN, we compared environmental variables for a species' full range to the subset of the range occurring within the rift. The median spatial overlap between a species' full range and the rift is only 1.6%. Repeated measures ANOVA shows that the rift is significantly ($p<0.05$) drier and has less tree cover and more grass cover than the full species ranges. These differences would have been less extreme in the Plio-Pleistocene when the elevational difference between the rift and its surrounds were less pronounced, but the direction of the bias would have been the same. Second, we used published morphometric datasets for extant baboons and guenons to ask: how good is the rift at sampling morphological variation in widely-distributed primate species? We quantified morphological variation in a 3-dimensional morphospace created using Principal Component Analysis on Procrustes coordinates. We compared morphospace sampling of the EARS to a) the full range of variation in baboons and guenons, and b) to sampling units of similar size and shape to the EARS scattered at random across Africa. Results indicate that the rift captures a modest proportion (<15%) of the overall morphological variation. It captures more variation in the baboon dataset than the guenon dataset. Overall, these results call for caution in making inferences about widely-distributed generalist primate species from spatially restricted occurrences.

**Acknowledgements:** Many thanks to Andrea Cardini, Sarah Elton, and Steve Frost for generously providing access to datasets.

## Exploring the Impact of Percussive Force in Flake Formation

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Force plays an important role in flake formation. Through replicative experiments, researchers have been focused on how force is ap-

plied and controlled during stone tool production. Yet, experiment results to date show conflicting outcomes. Modern knappers often believe that a more forceful strike leads to the creation of larger flakes, and some studies claim that modifying the striking force results in differences in flake proportions. In contrast, mechanical experiments repeatedly demonstrate that force does not significantly affect detached flakes. Specifically, beyond a certain force threshold needed to detach a flake, an increase in force would not affect the flake's size or shape. However, due to inherent limitations to the mechanical experimental design, it remains unclear how force influences flake formation as an independent knapping parameter. Here we present an experiment exploring the effect of force on flake size by using a custom-built synthetic hammerstone that can directly measure percussive force during knapping events. The hammer is composed of a deformable pneumatic 3D-printed chamber, connected to a sensor, encased within a 3D-printed grip and a stone-milled striker. We tested the relationship between force and flake attributes under different knapping conditions (e.g., anvil-supported and freehand), with specific focus on variation in flake size, shape, bulb of percussion, platform morphology, and termination type. The results provide new insight into the role of force application in the formation of lithic variability, which has important implications on understanding how hominin toolmakers controlled the flaking process.

**Acknowledgements:** CBM is supported by a University Postgraduate Award and an International Postgraduate Tuition Award from the University of Wollongong. This study was funded by an Australian Research Council Discovery Early Career Researcher Award Fellowship (DE200100502) awarded to SCL, with support from the Applied Mechatronics and Biomedical Engineering Research (AMBER) group, the Geoanalytical Laboratory, and the Lithics Laboratory at the University of Wollongong.

## Investigating the Mysteries of Bone Modification with the Smithsonian's National Taphonomic Reference Collection

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Taphonomy is essential for understanding biological, physical, and chemical processes that affect animal remains from the time of death until they are either recycled or become fossils. These processes cause many types of damage that can be used to reconstruct a bone's taphonomic history, but linking particular bone modification patterns to specific causes can be challenging. Different processes may result in similar damage features, such as the sharp, straight grooves caused by crocodile teeth, trampling, or human inflicted cutmarks. The Smithsonian's National Taphonomic Reference Collection (NTRC) offers comparative specimens that can help paleoanthropologists, zooarcheologists, paleontologists, and forensic scientists identify and interpret processes that cause post-mortem modification of modern and fossil bones. The NTRC is the first global taphonomy repository and includes modern bones (experimental and naturally occurring) from a wide range of well-documented taphonomic processes. Contributions by Behrensmeyer and zooarchaeologists Diane Gifford-Gonzalez and Gary Haynes form the core of this collection, but it is designed to grow with additions of both modern and fossil specimens representing a larger spectrum of bone modification processes. The NTRC specimen catalogue of accessioned specimens is available via the NMNH Paleobiology website (https://collections.nmnh.si.edu/search/paleo/). A partner collection is under development at the National Museums of Kenya, and our NMNH-NMK team is creating a searchable platform to link information from taphonomic collections across international museums via Symbiota (https://symbiota.org/). An interactive 3D reference atlas of NMNH specimens representing different taphonomic processes also will be available via the Smithsonian's 3D Digitization website (https://3d.si.edu/). Just as **Taxonomic** collections are essential for identifying vertebrate skeletal remains, **Taphonomic** Reference Collections such as the NTRC will provide comparative materials and "ground truths" for identifying specific bone modification features and linking these to known processes, agents, and ecological contexts.

**Acknowledgements:** Grant Information: National Science Foundation Collections Grant 1145777 to Gifford-Gonzalez and Haynes. We gratefully acknowledge contributions to the development of the NTRC and partner taphonomy collections by the Smithsonian Institution and scientific and collections staff at NMNH, the National Museums of Kenya Paleontology and Osteology Departments, and the Kenya Wildlife Service.

## Diachronic Zooarchaeological and Paleoecological Analyses of Late Pleistocene Sites in the Jabel Qalkha area, Southern Jordan: Evidence for Human Adaptability

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The Jebel Qalkha area in Southern Jordan includes sites ranging from the Middle Paleolithic (MP) to the Holocene. Today, the region is arid, with less than 50mm of annual precipitation. Here we compare the paleoecology of the region based on faunal remains of Tor Sabiha Layer 11 (late MP, n=80), Tor Hamar Layers G–F (Ahmarian, n=427), Tor Hamar Layer E2 (Qalkhan, n=35), and Tor Hamar Layers A-E1 (Mushabian, n=444). Results indicate a diachronic paleoecological shift from a wetter to a dryer environment. In the late MP, permanent standing water could support *Mauremys* sp. (pond turtle) with a dominance of *Capra* sp. (40%) over *Gazella* sp. (4.5%) and high proportions of *Equus* cf. *hydrantinus* (15.5%) and *Bos* sp. (7%). In the Qalkhan period, there was an increase in *Gazella* sp. (53%) and a decrease in *Capra* sp. (20%). However, *Bos* sp. (13.3%) frequencies are higher. The presence of *Nanospalax ehernbergi* supports a Mediterranean environment. The Mushabian layers are dominated by a further increase in *Gazella* sp. (61.5%) and *Capra* sp. (29.5%). A shift in *Bos* sp. and *Equus* sp. proportions attests to the decrease in local humidity between the Qalkhan and Mushabian. *Bos* sp. is more

common in the Ahmarian (0.7%) than *Equus* sp. (0.5 %). In comparison, the Mushabian *Equus* sp. is 2.5% while *Bos* sp. is only (0.5%). Observed shifts in human subsistence patterns and hunting strategies suggest adaptability to regional and local climate changes in the Late Pleistocene.

## Late Pleistocene Human Occupation of the Kilwa Coast (Tanzania): New OSL Dates and Paleoenvironmental Insights from Stable Isotope Data

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This paper presents new luminescence dates and stable carbon isotope data for a Late Pleistocene site called Mnaraeka (MN01) located in the Kilwa district, coastal Tanzania. The dates range from 71,000 to 10,000 years ago, bracketing an important period of hominin demographic and geographic expansion within and out of Africa. Eight soil samples subject to stable carbon isotope gave $\delta^{13}C$ values pointing to a wooded-mosaic habitat. The time span constrained by the new dates is known to have witnessed fluctuating global climate controlled by orbitally induced variability and the eruption of Mount Toba. Thus, it stands to reason that the coastal ecozone may have served as an ecological refugium during arid spells of the Later Pleistocene. The paper will also discuss the lithic assemblages from the site, which feature Levallois and blade knapping methods characteristic of the Middle Stone Age (MSA) technocomplex as well as a quartz-derived Later Stone Age component. Dominating the cultural record of humans from c. 300–40 ka, the MSA is pivotal in African prehistory as a hallmark of some significant shifts in hominin adaptive strategies (e.g., land-use and subsistence behaviors) and cognitive development that allowed hominins to adapt to diverse ecological settings. Thus, the discovery of lithic remains affiliated with this tradition at Kilwa has important implications for assessing the behavioral strategies that facilitated hominin adaptation to coastal East Africa. The study contributes to bringing the region to the spotlight of human evolutionary research.

## A Comparative Study of Maxillary Sinuses in Modern and Fossil Humans by Virtual Anthropology

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The maxillary sinuses are the greatest among paranasal sinuses. Their functionality is a matter of debate (Keir 2009), as it is their contribution to the evolution of human facial morphology. The latter topic draws great interest today in paleoanthropology, but its study is quite challenging due to the frequent fragmentation of these structures in fossils, and the lack of homologous landmarks available for geometric morphometrics analyses. This contribution aims at overcoming both issues by applying a 2D geometric morphometrics approach combined with a 3D volume assessment. This preliminary analysis included a sample comprising modern human digital crania of different geographical provenance (n=40) and fossil specimens of the species *Homo neanderthalensis* (n=6) and specimens commonly referred to as *Homo heidelbergensis* (n=5). A homologous plane was used to digitally cut the crania in a repeatable fashion so that a semi-landmark configuration of the transverse profile of the left maxillary sinus was sampled. The volume of the sinuses was calculated by using the R function *Icex* (Buzi et al. 2023), which allows the calculation if holes or gaps are present in the 3D model. The sample was then investigated by the intra-group variability, by dividing it into three groups corresponding to the different species. Two main vectors of changes could be seen in a principal component analysis, related respectively to their size and the orientation of the inner surface of the infraorbital plate. Some specimens of *Homo heidelbergensis* approached the Neanderthal cluster, consistently with their proposed closer relationship with the Neanderthal lineage. The volume data, on the other hand, clearly discriminates modern from all fossil humans. The results seem to suggest a possible phylogenetic signal in maxillary sinuses and highlight how inner cranial structures can contribute to a better understanding of human evolution and variation, once their study is made feasible by modern technologies and new implementations.

**Acknowledgements:** Museo di Antropologia G. Sergi, Sapienza Università di Roma, and Dr. Lynn Copes, Department of Biology, University of Florence.

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# StW 573 ("Little Foot") Limb Functional Anatomy and Behavioral Reconstructions, and Their Implications for Hominin Evolution

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The ca. 3.67 Ma skeleton known as 'Little Foot' (StW 573), recovered from Sterkfontein Member 2 breccia in the Silberberg Grotto, is remarkable for its morphology and completeness. This adult australopith preserves bilateral pairs of skeletal elements in proximal and distal limb segments, making it the earliest hominin with such an extensive representation of the appendicular skeleton. Cross-sectional geometric (CSG) properties acquired from these long bone diaphyses enable reconstruction of the loads that the individual incurred during inferred habitual locomotor activity. Here, we integrate investigations of CSG properties from multiple regions of interest (ROIs) in these elements, focusing on evaluations of interlimb proportions and strength-body size relationships. We compare StW 573 values to those of extant great apes and those of earlier, contemporary, and later hominins to assess evolutionary trends in limb loading. Humeral-femoral diaphyseal ROIs of StW 573 resemble those of chimpanzees, western lowland gorillas, and other australopiths more than those of modern humans or other *Homo* taxa, while ulnar-femoral diaphyseal ROIs corroborate these similarities. Relatively higher strength of the humeral and ulnar diaphyses than lower limb diaphyses evaluated against estimated body size suggests greater reliance on arboreal locomotor behaviors than typical for modern humans or fossil *Homo* taxa. Despite lower limb morphologies of StW 573 that are indicative of terrestrial bipedal gait, the CSG properties from many limb bones clearly demonstrate that arboreal activities also formed a selectively advantageous part of its locomotor repertoire, and likely earlier and contemporary hominins as well.

**Acknowledgements:** We thank the DSI-NRF of South Africa, The Palaeontological Scientific Trust (PAST), the University of the Witwatersrand, and the University of Southern California for funding this research.

# Lithic Technology and Human Adaptation in the Sicilian Upper Paleolithic

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This poster reports the findings of a systematic petrographic sampling of Siracusa and Ragusa, the first attempt at raw material sourcing in southeastern Sicily, and a technological reanalysis of the site of Pedagaggi's previously excavated stone tool assemblage. These analyses will determine how Sicily's first human occupants interacted with the island's ecosystems. This research has implications for understanding the deeply rooted relationships between human behavior and fragile island ecosystems. As the largest island in the Mediterranean (25,711km$^2$) and with land bridge connections to the Italian mainland during periods of lowered sea levels (Antonioli et al. 2016), Sicily is the most likely candidate for hosting the first human populations entering the Mediterranean islands ~16 thousand years ago. However, despite much research focused on the later occupations of Sicily, the prehistoric archaeological record and early environmental context of the island are largely unknown. The Pedagaggi cave (southeastern Sicily) was first excavated in the 1980s, where archaeologists recovered a lithic assemblage dominated by flint and typologically consistent with the Epigravettian of southern Italy. Thus far, study of the Pedagaggi assemblage has been minimal and limited to a typological analysis (Di Geronimo et al. 1981–1992), and as is the case for most of the Sicilian stone tools, raw material sourcing has not been attempted. Current evidence suggests that there are no local (<5km) sources of flint near the site. As such, all raw material was transported to the cave. The results of the technological analysis of the Pedagaggi lithic assemblage and geochemical sourcing of the flint raw material used at the site provide key insights into understanding how Sicily's first human occupants interacted with the island's ecosystems by tracing their use of past landscapes as measured through their use, transport, and discard of stone tools, either as part of daily subsistence activities or perhaps exchange with neighboring groups.

**Acknowledgements:** Thank you to the Center for Environmental Sciences and Engineering and the Institute of the Environment at the University of Connecticut for sponsoring this research. We thank Dr. Antonietta Rosso and the University of Catania for granting access to the Pedagaggi lithic assemblage. Thank you to Dr. Ellery Frahm (Yale University) for providing access to the pXRF and his generous guidance through the geochemical analysis process. We thank Huw Groucutt (University of Malta) for generously sharing some chert samples for inclusion in our dataset. Thank you to Agatino Reitano for generously sharing his raw material sourcing and knapping expertise. Thanks to the entire EOS team for their hard work and support!

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## Appearance of *Nycticebus coucang* in Late Pleistocene South China: Exploring Primate Biochronology and Paleoecology in Yahuai cave

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Understanding the biochronological and biogeographic distribution of primates in south China is critical for paleoenvironmental reconstruction of the region ca. 120,000 years ago. Primates can serve as a valuable proxy in understanding past environmental conditions that may have impacted human migration in the region, and the presence of a particular primate species in a specific area can indicate ecological corridors or barriers that may have influenced human movement. In this paper, we discuss the appearance of small primates and their significance to the site in Yahuai, Guangxi Zhuang Autonomous Region, South China. We analyzed the small fraction of bone remains wet-sieved through a fine mesh retrieved from area A dated to ~120,000–40,000 bp to identify primate dental and postcranial fragments. Identification was done by comparison with specimens from the University of Tulsa paleoecological and zooarchaeological collection and augmented by data from the literature. Preliminary results of the large fauna analysis suggest the dominance of *Macaca mulatta* (rhesus macaque); however, our wet sieving revealed the presence of the small-size *Nycticebus coucang* (slow loris) previously unknown from the site. *Nycticebus coucang* are nocturnal strepsirrhines currently facing habitat loss due to anthropogenic pressures with a scarce record in the fossil record. Results will discuss the importance of small primates in understanding the biogeography, biochronology, and taphonomy of the site, and how this finding sheds light on slow loris evolution.

## From the Middle to Later Stone Age on the African South Coast and Palaeo-Agulhas Plain: A Detailed Sequence of Transitions from Knysna Eastern Heads Cave 1

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Human evolution through the Middle Stone Age (MSA) encompassed a panoply of shifting technological, cultural, and behavioral strategies long acknowledged as key to understanding the origins of human modernity. The shift from the MSA to the Later Stone Age (LSA), as a population-wide occurrence, is also critically relevant to understanding the modern human adaptation. Emergent LSA strategies necessarily drew on, changed, and potentially replaced MSA adaptations in some areas, resulting in an aggressively successful and globally populous species. The record of this transition in southern Africa is tantalizingly complex (as recently surveyed by Bousman and Brink (2018) and Bader and colleagues (2022)), and is still poorly sampled within individual sites. Knysna Eastern Heads Cave 1 (KEH1), a south-facing site on the southern coast of South Africa, preserves a remarkable record of a relatively fast transition between the latest Middle Stone Age coastal foragers and the earliest Later Stone Age peoples recorded on the southern coastal plain. Here we present our first complete and detailed synthesis of the stratigraphy, site formation processes, and occupational intensity at KEH1, as well as preliminary environmental data. We find an intensive MSA occupation transitioning relatively quickly into an even more intense LSA occupation coincident with a significant environmental change. The evidence from KEH1 provides a platform for more detailed inquiries into questions of potential population replacement vs. adaptive change and is relevant to questions raised in previous surveys of the transition. Further, the temporal overlap between KEH1 and the sequence at the nearby inland site of Boomplaas (Pargeter et al. 2018) will ultimately result in a detailed regional framework for this key transition.

**Acknowledgements:** The authors acknowledge the generous support of the Hyde Family Foundation, John Templeton Foundation, Institute of Human Origins, L.S.B. Leakey Foundation, National Science Foundation (award #1523986 to NC), University of Texas Arlington, the African Centre for Coastal Palaeoscience, and Nelson Mandela University. In addition, we acknowledge Heritage Western Cape, the South African Heritage Resources Agency, IZIKO (The South African Museum), MAPCRM and SACP4, Woodbourne Trust, and the Knysna Municipality for assistance with permits and logistics. SW would like to acknowledge the National Science Foundation (award #2029578) and the University of California, Davis. BZ would like to thank GENUS (Centre of Excellence in Palaeosciences), Johannesburg, South Africa for funding her research.

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# Religious Sacrifice in the Ice Age? On Ritual Finger Amputation as a Potential Explanation for the Gravettian Hand Images with Incomplete Fingers

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Over 200 hand images with incomplete fingers (HIIFs) have been found among Europe's Ice Age cave paintings. Currently, the significance of these images, which are associated with the Gravettian (27,000–22,000 BP), is unclear. Some authors have argued the individuals who produced the images had all their fingers and simply manipulated their hands so that certain finger segments were invisible. Others have argued the images were produced by individuals who had undergone finger amputation. In 2018 we reported a study designed to shed light on the possibility that the Gravettian HIIFs reflect amputation (McCauley et al. 2018). We identified 121 recent societies that practiced finger amputation and distinguished ten motivations for engaging in it, nine of which did not involve a medical goal. We concluded that the hypothesis that best fits the Gravettian HIIFs is that they were produced by individuals who underwent amputation in religious rituals. Here, we do three things. First, we demonstrate that the main criticisms of our 2018 paper do not hold water. Next, we summarize the results of work we have carried out on this topic in the last few years. Most importantly, this work shows that amputation of fingers from living people for cultural reasons was even more common in the recent past than our 2018 survey indicated. It also shows that there is other evidence of finger amputation associated with the Gravettian. The third thing we do in this paper is discuss some implications of the Ritual Amputation Hypothesis. For example, we suggest it is worth considering whether finger amputation and other 'dysphoric rituals' might help explain not only the ability of Upper Paleolithic groups to outcompete non-modern hominins like the Neanderthals but also the emergence of the ethnolinguistic groups that appear to be reflected in the personal ornaments of the European Upper Paleolithic.

**Acknowledgements:** Our work on this paper was supported by the Social Sciences and Humanities Research Council of Canada, the Canada Research Chairs Program, the Canada Foundation for Innovation, the British Columbia Knowledge Development Fund, and Simon Fraser University.

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# Form or Shape? How Data Standardization Affects Results of Quantitative Genetic Analyses of the Primate Appendicular Skeleton

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3D landmarking is increasingly used to collect morphometric data for use in studies of human and non-human primate evolution. Such data are typically size standardized via Generalized Procrustes Analysis (GPA) to isolate shape for analysis; however, many anthropological studies incorporating evolutionary quantitative genetic methods instead use logarithmic transformation. This does not isometrically scale data, resulting in variables describing form (shape plus size). As shape and size vary even in closely related primate groups, analyses of form alone may confound our understanding of how shape alone evolves, and how shape and size covary. This is particularly pertinent to studies of hominins, a taxonomic group with apparent mosaic evolution and variable body size. Here, we compare the results of quantitative genetic analyses assessing evolutionary patterns affecting shape, size, and form by applying different methods of data standardization to the same dataset. Three datasets of 40 interlandmark distances on eight elements from the appendicular skeleton of six catarrhine genera were generated using different methods of standardization: log-transformation (form data), isometric scaling (shape data), and isometric scaling with element centroid sizes included as separate variables (shape and size data). Results of all analyses indicated the branch leading to *Homo* evolved under directional selection. Analyses of both form data and shape and size data indicated the branch to *Hylobates* was evolving under directional selection, while that of shape and size data indicated that the branch to *Pan* was evolving under directional selection. These results indicate that size may be a confounding factor in the evolution of shape. When using such methods to analyze evolutionary patterns in primates, analyses of shape and size as well as form may provide a more nuanced understanding of how shape has evolved over time while still allowing the constraining effects of evolutionary changes in size to be accounted for.

**Acknowledgements:** This material is based upon work supported by the National Science Foundation under grant number BCS-1830745.

# Shell Beads and Pigments Associated with Châtelperronian Artifacts at La Roche-à-Pierrot, Saint-Césaire, France

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La Roche-à-Pierrot is well-known for the 1979 discovery of a partial Neanderthal skeleton from what was described at the time as a Châtelperronian level (EJOP sup). Since then, the site has played a key role in discussions concerning the Middle-to-Upper Paleolithic transition in western Europe. Excavated by F. Lévêque over a period of 11 years, the collapsed rock-shelter of La Roche-à-Pierrot has produced a near complete stratigraphic sequence preserving late Mousterian to recent Aurignacian occupations (Lévêque et al. 1993). A recent reassessment of Lévêque's lithic assemblage highlighted both incoherencies in material culture associations and stratigraphy (Gravina et al. 2018). Since 2013, renewed fieldwork and geoarchaeological work have provided new important information concerning site formation processes, allowing spatial inconsistencies to be tested and the site's chronology and lithostratigraphic sequence to be reassessed (Couillet et al., 2022; Todisco et al. 2023). Here we present a concentration of Châtelperronian lithic artifacts associated with personal ornaments and red pigments from stratigraphic unit 18-19 (US18/19), correlatable with Léveque's EJOP sup. The personal ornament assemblage is dominated by marine gastropods of the genus *Littorina*, two thirds of which present clear anthropogenic perforations. While Middle Paleolithic artifacts are present in US18/19, a statistically supported, multi-proxy spatial and taphonomic analysis demonstrates the shell beads and pigments to be clearly associated with its Châtelperronian component. This is the first time that shell beads have been associated with the Châtelperronian. While anthropogenically perforated shells are unknown from Middle Paleolithic contexts, diverse perforated marine gastropods have been recovered from sites contemporaneous with the Châtelperronian in southeastern Europe and around the Mediterranean. This hitherto undocumented combination of a western European early Upper Paleolithic industry and shell beads provides new evidence for discussing cultural and/or biological connections between the various human groups present in Eurasia during this important period of human evolution.

**Acknowledgements:** The Collective Research Project of La Roche-à-Pierrot is funded by the Direction régionale des Affaires culturelles (DRAC) of the Région Nouvelle-Aquitaine and by the Département de Charente-Maritime (CG 17), France. Field research has also benefited from financial support of the research project of the Région Nouvelle-Aquitaine: Isotopes du calcium et anthropobiologie au Paléolithique moyen (n° 2019-1R40208), and from logistical and material support from Archéosphère. We thank the Service régional d'Archéologie (SRA) Nouvelle-Aquitaine, the Conseil départemental de la Charente-Maritime, and more specifically its Service d'Archéologie. This research benefited from the scientific framework of the University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past."

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# Was Symmetry an Entrenched Cognitive Trait That Organized Early Human Technologies? A Case Study of Fauresmith Prepared Cores from Kathu Pan 6, South Africa

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The emergence of *Homo sapiens* was a gradual and complex pan-African process. The technological innovations associated with these early humans show equally diverse patterns. Middle Pleistocene lithic technologies shifted from large, handheld stone tools (e.g., bifaces) to variations of early complex hunting technologies such as stone-tipped spears, some of the earliest evidence for which has been found in the context of Fauresmith assemblages from the Northern Cape, South Africa. The technological changes that emerged during the Middle Pleistocene are often implicated as a part of 'modern human' cognition. However, direct assessments of Middle Pleistocene lithics that evaluate the connection between such innovations and cognition are rare. Symmetry is often implicated in narratives of hominin cognitive complexity, beginning in the early Pleistocene with the shaping of Acheulean bifaces. Most studies describe symmetry quantitatively as a visual or physical aspect of the object. We can also consider symmetry qualitatively in the organization of technical gestures involved in knapping processes. The Fauresmith represents a period of transition from later Acheulean to Middle Stone Age technologies and roughly coincides with the emergence of *Homo sapiens*. Such transitional periods provide an opportunity to investigate processes of technological change and human cognitive evolution. Here, we explore whether symmetry continued as an entrenched cognitive organizing principle, in physical form and/or technological gestures, in Fauresmith prepared core flaking systems. Our study focused on prepared cores from a recently excavated site in the Northern Cape, Kathu Pan 6. We evaluated quantitative symmetry using a two-dimensional geometric morphometric analysis (Elliptical Fourier Analysis) and explored the relationship of this variability to qualitative symmetry in technological organization. Finally, we consider the implications of these results for potential changes in cognition associated with early *Homo sapiens*.

**Acknowledgements:** We wish to thank the McGregor Museum and all members of the field team who made this project possible. This work was generously funded by the Social Sciences and Humanities Research Council of Canada.

# Shelling Out the Details: Impacts of Variable Reporting of Chelonian Remains in Pleistocene Zooarchaeological Assemblages in Africa

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The order Testudines (informally: chelonians) includes all freshwater, sea, and terrestrial turtles and tortoises. Their remains offer important information about past hominin subsistence and environments and have been found at Pleistocene archaeological sites (2.53–0.117 Ma) across Africa. However, collection and reporting strategies vary across space, research intensity, and research team, making it challenging to understand spatial and temporal trends in the record. We examined the published record for chelonian remains across archaeological sites from Africa (n=125 sites), recording for each: 1) lowest taxonomic level, 2) assemblage quantity (NISP, MNE, or MNI), 3) skeletal element, 4) taphonomy, and 5) agent of accumulation. Most sites with chelonian remains were from eastern (45%) and southern (41%) Africa. Sites with more detailed information were typically in southern Africa. Of all 125 sites, 75% reported the quantity of remains, and 49% mentioned at least one skeletal element. Habitat preference varies across taxonomic categories, making this information useful for reconstructing past environments. However, more than half (51%) of sites reported chelonian remains only to order, while 8% reported family, and 41% reported genera or species. Taphonomic analysis is essential for understanding the potential role of chelonians in hominin diets, but overall, only 21% of all sites reported chelonian taphonomy. In spite of this, 80% implied hominins as agents of accumulation. Further study of chelonian remains, including more consistent reporting, has much potential for understanding hominin paleoecology in Africa.

# Using Geography and Irrigation Practices to Create a Model to Identify *Schistosomiasis* Cases in Egyptian Mummies

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Confirming cases of diseases in mummies is vital to understand the disease, its origins, evolution, and its effects on modern populations. Currently there are not many confirmed cases of *Schistosomiasis*, a waterborne illness transmitted through snails that still affects modern populations, so is vital that we try to understand as much as we can about an illness that has affected Egypt for thousands of years. This study's aim is to see if geography and irrigation practices are useful variables in creating a model to guide the selection of Egyptian mummies that would make the best candidates to test for *Schistosomiasis.* The hypotheses of this study use the following parameters to guide mummy selection: (1) the correlation between prevalence rates and geography in four quadrants of Egypt and (2) the type of irrigation practice used (seasonal/basin vs. perennial). Currently there is high prevalence of the disease in two quadrants of modern Egypt (areas 1 and 3); one of these areas (area 1) was not a common burial site in ancient Egypt, but the other (area 3) overlaps with multiple confirmed cases of the disease in mummified remains, and also

with the use of perennial irrigation. Since so many of the confirmed cases of *Schistosomiasis* in mummies correlate with both geographic location and type of irrigation practice, this model seems promising as a tool to help guide genetic and paleoepidemiological research in the future. Confirmed cases in Nubia also follow this pattern, adding confidence to the use of this model.

## Exploring Environmental Drivers of Hominin Scavenging Behavior: A Modeling Approach

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Environmental change is argued to drive milestones in human evolutionary history. However, the mechanisms that link changes in aridity and expanding grasslands to shifts in hominin biology, behavior, and diet remain unclear. By approximately 2.0 Ma the fossil and material record shows evidence of persistent hominin carnivory indicated by cut marked bones and stone tools. It is necessary to understand the environmental drivers that likely contributed to the expansion of animal tissue consumption behaviors. Changes in moisture in the environment impacts the availability of surface water (semi-permanent watering holes) on a landscape. In semi-arid environments, numerous taxa are water dependent, thus surface water structures patterns of animal movement. Here, we develop an agent-based model to explore the impact of surface water abundance on the frequency of scavenging events occurring on a landscape. Agents, herbivores and hominins, move around modeled landscapes with varying numbers of water sources. The agents maintain a stable population with a set death rate. Hominins can access animal tissue when they encounter a dead herbivore. Preliminary results show that increasing water sources on the landscape reduces scavenging encounters (slope= -0.28, $P<0.001$, R-squared=0.89), presumably because the location of herbivores and thus carcasses is less predictable. Our agent-based model shows how environmental changes can dramatically change the baseline frequency of scavenging opportunities without changing the behavior of agents. We argue that environmental change should be carefully considered as one possible explanation for changes in the frequency of evidence of animal tissue consumption in the fossil and behavioral records.

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## Exploring Early Hominin Carnivory: Insights from the Newly Discovered Area 8A Fossil Assemblage in East Turkana, Kenya

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Our study delves into early hominin carcass acquisition practices, examining a unique fossil assemblage from Area 8A in the Ileret subregion of the Koobi Fora Formation (KFF), dating from 1.87 to 1.56 million years ago (Ma). This assemblage, from the KBS Member, is significant as it predates the Okote Member assemblages in East Turkana (1.56–1.38 Ma), which are widely recognized for their insights into Early Stone Age butchery. Unique within the KFF, the Area 8A assemblage includes hominin remains, stone artifacts, and evidence of butchery, featuring over 1,000 mammalian specimens, with more than 500 identified to taxonomic family. This research enhances our comprehension of hominin carcass processing at a crucial evolutionary juncture and fills a temporal gap in our understanding of hominin carnivory in East Turkana. We provide a comprehensive analysis of the assemblage, including taxonomic composition, ungulate size class distribution, weathering stages, skeletal part representation, and bone surface alteration patterns. The notable abundance of small-sized (size 2) ungulate fossils, predominantly in early weathering stages (0–1), indicates a distinctive carcass accumulation pattern, contrasting with the later Okote Member assemblages. The high ratio of epiphyses to shafts, along with scant evidence of carnivore-induced damage, points to a lesser role for carnivores in this assemblage's formation and alteration. This finding contrasts with the Okote Member assemblages, where there is more pronounced evidence of carnivore interaction, hinting at potential variations in hominin carcass acquisition strategies. Our findings align with models where hominins are not the primary accumulators. However, the frequent cutmarks on long bone midshafts suggest that hominins had access to carcasses shortly after death. This study contributes significantly to our understanding of early hominin carnivory during a key phase of human evolution.

**Acknowledgements:** This work was funded by a grant from the Leakey Foundation (Spring, 2023). This research was also supported by funding from the NSF-REU program (1852441) and the NSF-SBE Archaeology program (1624398).

# A New Non-Destructive Method for the Identification of Fossilized Burned Bones in the Archaeological Record

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Fire played a critical role in shaping hominin behavior, yet there are gaps in the available methods for how to identify fossilized bones that were burned, which limits our ability to identify occurrences of fire in the archaeological record. Currently the field of archaeology lacks a non-destructive method to identify whether fossilized bones have been burned or not. This project aims to discover a method to identify which fossilized bones with butchery marks are more likely to have been burned, so as to decrease the need for destructive testing. Deer bones were experimentally cut-marked and/or percussed and then burned for different durations of time to simulate both waste disposal and cooking. There were two experimental tracks; cut-marked bones were either placed on a fire or first percussed with a stone anvil and hammerstone to simulate marrow extraction prior to being burned. The burned bones were examined under a microscope at 35X magnification to identify taphonomic trends in breakage patterns. A modified version of Domínguez-Rodrigro's (2014) variables were followed to observe the cut marks, heat fracture locations, and to compare burnt and unburnt bones. This work is important because it looks at how fire affects the preservation of butchered bones, which can help interpret archaeological indicators of butchery practices. This project has implications for the methods that paleoanthropologists and zooarchaeologists use to study early hominin fire use.

**Acknowledgements:** Special thanks to Sarah Hlubik, Frances Forrest, and Scott Smith for their unwavering support.

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# A Partial Parietal Hominin Bone from the 2023 Campaign at the Middle Pleistocene Site of "Ruidera-Los Villares" (Ruidera, Spain, Iberian Peninsula)

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After road construction in the 1960s, faunal fossils were surface collected by locals at the "Los Villares" house state (Ruidera, Ciudad Real). The study of the fossils showed the presence of cutmarks on some herbivore bones dated around 300–400 Kya by a combined ESR-Uranium series approach (García Martínez et al. 2022). A systematic excavation of 10m$^2$ was carried out in 2023 to clarify the spatial and stratigraphic extension of the fossil assemblage. We observed that the site is formed by red breccias with speleothem fragments, interpreted as the sedimentary infill of an eroded rock shelter, some of them being in a secondary position. The faunal analysis showed that small bovids dominate the association, although the greatest diversity is found among carnivores. The mammal community is compatible with other Iberian sites from the late Middle Pleistocene, suggesting a rocky ecosystem with scattered vegetation. The small lithic tools assemblage consists of quartzite cores and flakes with few extractions, possibly attributed to an ancient industry. Finally, among the fossil remains found during this campaign, a partial human parietal bone from a large hominin stands out. The fossil, about 8x7x1 centimeters, preserves enough morphological features to make its anatomical assessment as part of the coronal suture and the temporal line, as well as a "human-like" middle meningeal artery imprint (Bruner and Sherkat 2008). The possible attribution of a precise species of the genus *Homo* and the confirmation of its potential chronology is an ongoing investigation, but if the date of 300–400 Kya obtained for other fossils is confirmed, it could represent a unique human fossil, the single one of this period in the southern Ibe-

rian Peninsula and could shed light on the peopling of Western Europe and the evolution of different human lineages.

**Acknowledgements:** We thank Antonio Ruiz Reinosa, guard of the house state, for their kindness and collaboration regarding the preservation of the archaeo-paleontological heritage in Los Villares. We also want to acknowledge Ignacio Mosqueda (Parque Natural de las Lagunas de Ruidera), Josefa Moreno (Ruidera mayoress), and Omar Collado (Albergue juvenile Alonso Quijano). Finally, we want to thank the excavation team for their great work: Francisco Ceprián, Cristian Chico, Daniel Sanz, Eduardo Solana, and Yan Yvaylov. DGM is funded by the PR3/23-30817 project (UCM), and the excavation campaign was funded by www.goteo.org and institutions such as the Laboratorio de Poblaciones del Pasado (UAM).

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## Maximizing the Impact of Public Outreach: A Case Study in Sicilian Paleolithic Archaeology

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Public outreach promotes relationships between researchers and local stakeholders, which can further improve research outcomes and benefit the communities where research occurs. Developing initiatives that consider stakeholder interests and are relevant to their needs is key to the success of a public outreach project. However, identifying effective strategies may be challenging because interests may vary widely between different stakeholder groups and across projects. Here, we present the outreach strategy of the Early Occupation of Sicily Project (EOS). EOS is an archaeological project that researches the timing and modes of early migrations and occupations in Sicily, the first Mediterranean island to be colonized by humans (~17 kya). In Sicily, the lack of exposure to Paleolithic archaeology in comparison to other time periods has led to a general disinterest in the topic by the public and institutions alike. EOS' outreach strategy includes a collaboration with the Municipal Museum of Natural History of Comiso (MMNHC) for the creation of three bilingual educational panels on Paleolithic archaeology, human evolution, and research methods. The panels accompany a new archaeological exhibit at the MMNHC but were also made to act as self-standing materials that can be displayed in other institutions such as schools and libraries. We found that the presence of these panels in public spaces, in combination with a series of public lectures, has increased local interest in prehistory in general and in our project in particular. This has subsequently resulted in the creation of citizen science workshops and a more friendly response to our survey work when on private or military land. We believe that the success of our strategy lies in our collaboration with the MMNHC; this relationship was key to successfully ensuring that our work was audience-centered, and we believe that this strategy may prove effective in similar contexts.

**Acknowledgements:** We acknowledge the local communities of Augusta, Brucoli, and Ragusa that have hosted us and shared with us their knowledge of the landscape and local history. In particular we would like to thank Mr. Russo, Mr. Patania, Mr. Houpt, Dr. Federico Salmoiraghi, Professor Mariada Pansera of the Archeoclub Augusta, and Professor Mariagiovanna Sergi. Funding for this project was provided by grants to Patania from the Leakey Foundation and the Rust Family Foundation, and to Garnett from the Newman Exploration Travel Fund and the George R. Throop Endowment at Washington University in St. Louis.

## Measuring Early Levallois Blank Utility and Standardization: A Novel Approach

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Levallois prepared core technology and its purpose has been a point of intrigue for Paleolithic archaeologists since its initial discovery in the Levallois-Perret suburb of Paris in the 19th century. Here we continue this tradition by exploring factors that may be responsible for the early use of this technology at the Lower–Middle Paleolithic (LP–MP) boundary in the Armenian Highlands. To investigate this, we first propose and experimentally verify a novel method for measuring flake utility and standardization from core-scars on 3D scans. We then apply this technique to 3D scans of cores recovered from the LP–MP transitional site of Nor Geghi-1 in the Hrazdan Gorge of central Armenia. Our results indicate that factors driving the later widespread adoption of Levallois production may differ from those responsible for the earliest development of the core technology, which suggests chronological transformations in the functionality of Levallois prepared cores over the course of the late-Lower and Middle Paleolithic.

**Acknowledgements:** The research reported here was possible thanks to funds provided to J.P. Gill and D.S. Adler by the National Science Foundation's Doctoral Dissertation Research Improvement award (#2012112). The authors would like to thank Hrazdan Gorge Palaeolithic Project participants and undergraduate field school students from the University of Connecticut. We would also like to thank the Ministry of Culture of the Republic of Armenia and Pavel Avesetyan, Director of the Institute of Archaeology and Ethnography, National Academy of Sciences, for continued support of our archaeological fieldwork. J.P. Gill would further like to thank A. Barun (Boston University) for assisting with 3D scanning, and N. Munro and C. Tryon (University of Connecticut) for their helpful feedback on this manuscript.

# Vole (*Microtus guentheri*) Stable Isotopes as Proxies for Paleoenvironments: Implications for Modern Human and Neanderthal Interactions in the Middle Pleistocene Levant

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The environmental contexts of Archaic Modern humans (*H. sapiens*) and Neanderthals (*H. neanderthalensis*) in the Middle Pleistocene of the Southern Levant have implications for understanding how both species interacted within a small geographic region characterized by a sharp ecotone. Generally, Archaic Modern humans have been thought to have occupied warmer and dryer periods in the Levant (i.e., MIS 5e). In contrast, Neanderthals are considered to have inhabited cooler, more humid periods (i.e., MIS 6 and MIS 4). Previous studies that relied on rodent community structure as a proxy for environmental reconstruction have argued that a high abundance of voles (*Microtus guentheri*) common in both Hayonim and Rantis caves dated to MIS 6 indicates open and dry environments contradicting the hypothesis above. Moreover, recent discoveries of *H. sapiens* at Misliya Cave (ca. 200–170 ka) and the site's rodent community structure point to a more variable climate than simply hot/dry or cold/humid one. To further this discussion, carbon and oxygen-stable isotopes from dental enamel were extracted from a population of *Mus macedonicus* from Rantis (n=10) and Hayonim Caves (n=10). Results were compared to modern *Mus macedonicus* from Israel (n=10). Mice are omnivore species hypothesized to shift their diet according to the relative abundance in the environment. Results suggest that Rantis and Hayonim were cooler and more humid than today. Supporting the hypothesis that the climate and environment across the ecotone of the MP Levant were complex, with a more nuanced relationship between hominin species and their preferred habitats. Furthermore, these preliminary results demonstrate the importance of looking beyond community structure toward a more robust paleoecological indicator.

**Acknowledgements:** Funding was provided by The University of Tulsa Student Research Grant Committee and the George H. Odell Anthropology Foundation.

# Identifying the Lithic Reduction Strategy at Middle Stone Age Vleesbaai (South Coast, South Africa) Using a Novel Refitting Approach

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Vleesbaai is a half-moon bay just west of Pinnacle Point preserving intact paleosols dated from 120–50 ka and thus temporally overlapping the Middle Stone Age (MSA) sequence of Pinnacle Point. Numerous MSA sites are found stratified and in outstanding context at Vleesbaai. Vleesbaai Area B and C have been extensively excavated, and Area B has been dated by optically stimulated luminescence (OSL) and the Toba cryptotephra to ~74 ka. The nearby rockshelter site of PP5-6N at Pinnacle Point (PP) also preserves layers containing the Toba isochron. Situated approximately 7km from PP5-6N, Vleesbaai is within the daily foraging radius of hunter-gatherers residing there, and artifacts recovered from there were likely deposited by the same groups occupying the caves at PP5-6N. This presents a unique opportunity to study variation between open-air and cave/rockshelter sites, raw material economy, and site function during the MSA. Excavations of three primary areas at Vleesbaai beginning in 2014 recovered objects including 2,259 lithic artifacts that were recorded for qualitative and metric data. Observations during data collection were used to group artifacts into raw material categories to facilitate a large-scale refit study of the lithics from Vleesbaai Area-B and Area-C. Here we present novel methods used to organize and record the refit study as well as the results which included 56 conjoining units (partially refitted nodules) with 157 unique conjoins (refitting surfaces between artifacts). The recorded data along with the refit study support an interpretation of early-stage reduction, likely the result of raw material procurement activities. It is hoped that these methods can not only be applied more broadly to lithic materials from Pinnacle Point and Vleesbaai, including those potentially recovered in future excavations, but also to other suitable assemblages.

# Comparative 3D Shape Analysis of the Iwo Eleru Mandible, Nigeria

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The Iwo Eleru skeleton is the only Pleistocene human fossil currently known from Western Africa. Previously, we showed morphological affinities of the Iwo Eleru cranial remains with Pleistocene archaic African specimens, consistent with former interpretations of this specimen (Harvati et al. 2011). Those results suggested deep population substructure in Africa and a complex evolutionary process for the origin of modern humans, potentially involving hybridization between Later Stone Age modern human populations and late surviving archaic lineages. Here we conduct a geometric morphometric comparative analysis of the Iwo Eleru mandible to shed further light on the specimen's morphology and evolutionary relationships. We used twenty-five three-dimensional landmark coordinates, collected from a comparative sample comprising Pleistocene and Holocene *Homo sapiens*, as well as *Homo neanderthalensis* and Eurasian Middle Pleistocene *Homo* samples. Results show that the Iwo Eleru mandible is most consistent with the shape variation found in

North African *Homo sapiens* from Epipaleolithic contexts, but in overall shape and in its large size. These findings are discussed in the temporal and geographic framework of the Iwo Eleru skeleton.

**Acknowledgements:** Harvati is supported by the ERC AdG 101019659 'FIRSTSTEPS', the DFG FOR 2237 and the University of Tübingen. Stringer is supported by Calleva Foundation (Grant Number SDV17014) and the Human Origins Research Fund.

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## The Potential of Crypto-Tephrochronology Studies at Paleoanthropological Sites Throughout Africa

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Volcanic ash (tephra) has been instrumental in constructing age models and correlations between archaeological and paleontological sites for decades. More recently, the significance of tephrochronology at sites in South Africa was recognized through the discovery of the 74 ka Youngest Toba Tuff (YTT) at archaeological sites Pinnacle Point 5-6N and Vleesbaai (Smith et al. 2018). Deposits of the YTT have been mapped across most of Sumatra, India, and the North China Sea, along with cryptotephra in eastern and southern Africa, providing a widespread isochron for paleoenvironmental and archaeological deposits. However, accurately documenting the extent and the geochemical variability of the YTT along with other volcanic eruptions is important for properly identifying this isochron and thus its significance to human evolution. Here, we report on two groups of cryptotephra (Mode A and B) at three archaeological sites (Klasies River Cave 1A, Diepkloof Rock Shelter, and Kathu Pan 6) and in one sediment core (Tswaing Crater core) in South Africa. Both modes are high-silica rhyolites, with Mode A depleted in heavy rare earth elements (HREE) compared to Mode B. Based on an extensive geochemical search of Pleistocene eruptions, we suggest that shards from all four localities are part of the YTT. We also report on evidence of a younger cryptotephra population, potentially sourced to an East African eruption, present at Kathu Pan 6. These findings validate the potential for YTT and other cryptotephra horizons to be crucial additions to the geochronological toolbox throughout Africa (and beyond), which is essential for establishing highly precise isochrons across the stone age record worldwide.

**Acknowledgements:** We would like to gratefully acknowledge Christine Lane from the University of Cambridge and Benoit Caron from Sorbonne Université for help with geochemical sourcing. We also acknowledge funding from the following agencies and organizations: National Science Foundation; the Institute of Human Origins (IHO) at Arizona State University (ASU); Graduate Professional and Student Association (GPSA); and the Hyde Family Foundation.

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## Examining the Stable Isotope Variation of Mammals in South Luangwa National Park in the Context of Anthropogenic Influences

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The South Luangwa National Park in Zambia has a rich history that continues into the modern day. National Parks are treated as 'pristine' environments devoid of human influence—however, they are created and managed by humans. The people living in the South Luangwa National Park were displaced due to the creation of the park—yet their influence on the park's ecology has remained strong. Both the tourist industry and the unfenced boundaries of South Luangwa National Park support interactions between wildlife and humans, including the surrounding villages. Using stable carbon and nitrogen isotopes, we examined foodwebs of large mammals in the South Luangwa National Park. We also use processed satellite data to examine human alteration. We collected 59 bone specimens from 13 species of large mammals (i.e., hippos, antelopes, giraffes, zebras, buffalo, carnivores) using standardized surface survey from both inside and outside the park. Samples were pretreated, then put into the EA IsoLink CN analyzer and Delta V Plus Isotope Ratio Mass spectrometer to determine their carbon and nitrogen isotope signals. Using satellite data that examines different anthropogenic influences, such as roads, we show that anthropogenic alteration differs across the park, but especially between the interior and exterior of the park. Though the park is classified primarily as a woodland, we find grazer and browser specialists. There is also trophic discrimination and niche partitioning among carnivores. Our results highlight the complexity of the area and add the context necessary

to assess anthropogenic effects on mammalian diets both in the present and in the archaeological past.

**Acknowledgements:** Our research is supported by a Franklin Grant from the American Philosophical Society, the Earthwatch Institute, the Connor Family Faculty Foundation, and research grants from Virginia Commonwealth University, the University of Arkansas, and Western University of Health Sciences. Our work would not be possible without the active guidance, expertise, and cooperation of the Zambian National Heritage Conservation Commission (NHCC) and the Department of National Parks and Wildlife (DNPW). We thank Steve and Anna Tolan for their dedication to conservation and research in the South Luangwa National Park.

## Phytoliths as an Environmental Proxy for the Upper Paleolithic in the Armenian Highlands – Aghitu-3 Cave, Armenia

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The Armenian Highlands together with southern Caucasus is a biodiversity hotspot, encompassing a spectrum of environments from temperate forest to semi-desert steppe. Having experienced hominin occupation since 1.8 Ma, the region offers a unique opportunity to study the expansion and evolution of the genus *Homo*, as well as its interaction with the local environment. Here we build on a previous study using phytoliths as a proxy for paleoenvironmental reconstruction. Aghitu-3 is an Upper Paleolithic cave site in southern Armenia, positioned above the modern Vorotan River. Thirty-three radiocarbon dates across five archeological horizons show occasional occupation between 39,000–32,000 cal BP and again, more intensely, at 29,000–24,000 cal BP. Thorough investigation of the site, including pollen, charcoal, and both micro- and macrofauna, has shown that early occupation corresponds with moist, mild to warm climatic conditions. Human activity at the site is all but absent between 32,000–29,000 cal BP as the climate initially cools, but more intense occupation follows between 29,000–24,000 cal BP. Phytoliths were extracted from 61 sediment samples spanning the five archaeological horizons. The results of their analysis were contrasted with modern phytolith assemblages from known vegetation units using relative abundances and Linear Discriminant Analysis. The data show local environmental fluctuations over time and how these correspond to periods of human occupation. In addition, distinct anthropogenic signals during the later period of intense occupation give insight into the subsistence strategies of these Upper Paleolithic humans.

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## Palaeoecological Implications for Hominin Dispersal(s) Through the Pinjor Formation of the Upper Siwalik Hills near Chandigarh in Northern India

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The role of environmental stimuli in human evolution, expansion, speciation, adaptation, and extinction has been highlighted time and again by scholars. Global climate change from forest-dominated to grassland-dominated environment in the Plio-Pleistocene period has been identified as an important factor for hominin dispersal around the Old World. However, in light of recent research this is being questioned and debated. The fossils of *Homo erectus*, one of the first known early human species to disperse outside of Africa, have been discovered from Early Pleistocene deposits of East Europe, West Asia, and Southeast Asia, thereby placing the Indian Subcontinent in general—and the Siwalik Hills in particular—as an important dispersal route. However, apart from the chronologically and taxonomically ambigous Hathnora cranium, no unequivocal fossil hominin remains have yet been reported from the region. Based on the presence of fauna often associated with *Homo erectus*, like *Theropithecus oswaldi*, *Hippopotamus*, and *Megantereon* in the Early-Middle Pleistocene deposits of the Siwalik Hills, scholars have predicted the presence of hominin remains in the region, yet none have been found. Currently, lithic artifacts are the only known signatures of hominin occupation in the region, primarily occurring as surface deposits without secure dates. The Pinjor Formation (2.58–0.63 Ma), north of Chandigarh, in northern India, represents the most extensive and the only continuous Early-Middle Pleistocene deposit in the region with a rich record of fossilized vertebrate remains and, recently, ostrich eggshells. In light of absence of stratified lithic deposits and secure dates, palaeoecological and faunal analogies with other Early-Middle Pleistocene hominin bearing sites, can provide an adequate explanation for presence/ absence of hominins in the region. My research focuses on understanding paleoecological implications for hominin dispersal(s) through this region, using dental ecomorphology and biogeochemical analysis. Overall, this research provides a better understanding of the human-animal-environment interface in the region.

**Acknowledgements:** Field volunteers: Anshika, Tarannum Caur, Rituja, Rakshanda, Ananya; Field assistants: Lakshay Verma, Nisha Menon and Atashi Maitra; Villagers from all field sites for their hospitality and assistance during excavation; University of Utah for processing Stable Isotope samples; and, Funding: Lithic Studies Society, Paleontological Society, Royal Anthropological Institute, Leakey Foundation, Society for American Archaeology, Palaeontological Association, Smithsonian Institute, Indian Institute of Science Education and Research Mohali.

## Taphonomic Analysis of Middle Stone Age Ostrich Eggshell Fragments from Pinnacle Point 5-6N (South Coast, South Africa) Reveals Changes in Occupational Intensity

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During the Quaternary, global glacial cycles alternately exposed and inundated the Paleo-Agulhas Plain (PAP) along the southern coast of South Africa. These large-scale environmental shifts impacted floral and faunal communities, resulting in changing resource densities and impacting the humans who foraged along the PAP. Reconstructions of the PAP show a rich floodplain that included swaths of grasslands (Cowling et al. 2020), offering ostriches (*Struthio spp*.) abundant resources, and likely resulting in ostrich migrations or population reduction when the PAP was submerged. Ostrich eggs are an important nutritional (~2000 calories/egg) and technological resource, as the eggshell can be manufactured into flasks and beads. Pinnacle Point 5-6N is located on the northern margin of the PAP, adjacent to the modern coastline. This sequence (~100–50 kya) spans multiple ocean regressions and transgressions, during which humans and hyenas continued to source ostrich eggs primarily from the PAP (Hodgkins et al. 2018). Although ostrich eggshell fragments (OES) are recovered across the sequence, we observe changes in density across time. We examine the hypotheses that 1) shifting coastlines resulted in fewer available eggs; or 2) changes in the intensity of the site use resulted in differential fragmentation. We provide a taphonomic assessment of ~2,000 ostrich eggshell fragments from both the piece-plotted and screened material to test these hypotheses. Our results suggest that fragmentation patterns are driven by occupational intensity, and that foragers continued to collect and transport eggs to the site despite the encroaching coastline.

**Acknowledgements:** This project is funded by a NSF Doctoral Dissertation Improvement Award (BCS- 2231806), the Yale MacMillan Center, Yale Council on African Studies, and Yale Anthropology Department. We appreciate the support of the MAPCRM and SACP4, and Iziko Museums.

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## Beyond Extinction: Modelling Diverse Neanderthal-*Homo sapiens* Interactions

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Models of Neanderthal-*H. sapiens* interaction generally build off of the premise of Neanderthal extinction, seeking model parameters that produce such a result. These models primarily invoke competition as a causal factor. This is a logical starting point, as Neanderthals did eventually go extinct, potentially due to interactions with, or merely the presence of, *H. sapiens*. However, genomic analyses have revealed examples of interbreeding between various populations of both species, suggesting that not all interactions necessarily resulted in the local extinction of one group through competition. It is also true that the Middle-to-Upper Paleolithic transitional record is sparse in fossil evidence, so that *H. sapiens* authorship of most Upper Paleolithic assemblages is assumed rather than demonstrated. Therefore, if we wish to holistically reconstruct the range of possible local interaction scenarios between Neanderthals and *H. sapiens*, rather than seeking to explain the ultimate global outcome of these processes, we must expand the scope of our models to allow for coexistence and cooperation in addition to competition and extinction. A common way to model inter-species interactions is through the use of Lotka-Volterra predator-prey models. This study adapts a Lotka-Volterra-type persistence of predators model originally proposed by Goldfield et al. (2018). Goldfield et al. assert that their model has four possible equilibria: extinction of all species, extinction of both hominin species, the extinction of Neanderthals, and the extinction of *H. sapiens*. This paper instead explores model parameters in which coexistence is maintained, accomplished by varying levels of competition, cooperation, niche partitioning, and population mixing between model runs. Even if *H. sapiens* had an inherent metabolic advantage, as assumed by Goldfield et al., both populations could be maintained locally even with only intermediate levels of cooperation, niche separation, or interbreeding. Furthermore, interbreeding could lead to Neanderthal extinction even in the absence of competition.

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## The Aggregation Problem: Implications for Paleoanthropology

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How do we cut up the Great Rift Valley? Where we delineate our datasets matters. The "aggregation problem" is a dilemma wherein combining heterogeneous phenomena requires the observer to choose the unit of analysis. This choice is reflected in the results and depends on the researchers' goals and underlying theory. Results from analysis of $\delta^{13}$Cenamel data from archaeological and paleon-

tological contexts and regional inter- and intra-basin studies of enamel and pedogenic carbonates from contemporaneous locales in eastern Africa highlight the importance of local environments and regional heterogeneity. Aggregating these data in different temporal and spatial scales yields different interpretations of the environment. In a study of fossil enamel stable isotopes from Gona, results of carbon stable isotopes indicated an increased prevalence of C4 resources coinciding with the emergence of Acheulean technology. However, when these data are separated, and assemblages associated with stone tools are compared with assemblages from areas with no artifacts, this environmental signal is only visible in the archaeological assemblages. This suggests researchers use caution when aggregating data from different formations and archaeological contexts in paleoenvironmental reconstructions since hominin behavior can bias assemblages associated with stone tools. Alternatively, this could be a problem with sampling bias, differential deposition, or sample sizes. This paper explores the problem of aggregation and how paleoanthropologists should combat this problem through intentional study design.

**Acknowledgements:** We would like to thank the Authority for Research and Conservation and Cultural Heritage (ARCCH) of the Ministry of Culture and Tourism of Ethiopia for research permits. The Culture and Tourism Bureau at Semera, the capital of the Afar Regional State, provided local permits and assistance for the Gona fieldwork. We would also like to thank the L.S.B. Leakey Foundation, the Wenner-Gren Foundation for Anthropological Studies, Yale Institute for Biospheric Studies, Yale MacMillan Center, Sigma Xi, and the Council for Archaeological Studies, Yale University for funding this research. We would also like to thank colleagues at the Isopaleolab at the University of Michigan and Brad Erkkila at the Yale Analytical and Stable Isotope Center for their contributions.

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## The Omo-Turkana Basin Hominin Fossil Record

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An exhaustive hominin fossil catalog is itself an important object of study. The analysis of the characteristics of such a record can make significant contributions to the study of hominin evolutionary history. Based on 115 bibliographical references, we illustrate this using the hominin record from the Omo-Turkana Basin (Kenya-Ethiopia), where intensive paleoanthropological research began in 1967. To date, the hominin fossil record contains 1,231 published remains. The analysis of this record provides a quantified critical perspective that helps us to gain a better understanding of the biases affecting it, such as anatomical representation and difficulties with taxonomic identifications of some specimens. It also provides an historical perspective illustrating the contribution of hominin fossils from the Omo-Turkana Basin to our knowledge of hominin evolution. Furthermore, our study illustrates the chronological framework and hominin diversity in the Omo-Turkana basin as well as the relative abundance of *Paranthropu*s and *Homo* remains (2/3 and 1/3 respectively) during their long period of coexistence. We also show that, illustrated by a significant number of remains, and contrary to the prevailing view, the genus *Homo* was well established in the Omo-Turkana basin between 2.7 and 2 Ma. Finally, we show that the fossil record of the Upper Burgi Member, and to a lesser extent the KBS Member, is atypical, both in terms of anatomical representation and taxonomy, which cannot be fully explained by either paleoenvironments or taphonomic or collecting biases.

## New Insights into Magdalenian Subsistence at Petersfels (Hegau Jura, Southwestern Germany)

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At Petersfels (Hegau Jura, southwestern Germany), one of the most prolific Magdalenian sites in Central Europe, nearly one hundred years of excavation and research has revealed an exceptional record of human occupation from 15,000 years ago. Unstudied faunal remains (n=3256) from a 16m$^2$ area in front of the cave (P6 excavation area) provide an opportunity to assess the site from a modern perspective. Reindeer (*Rangifer tarandus*) dominate the assemblage followed by hare (*Lepus* sp.), horse (*Equus ferus*), and ptarmigan (*Lagopus* sp.). The faunal remains are well-preserved and exhibit abundant cut marks, impacts, and green breaks, attesting to the highly anthropogenic nature of the assemblage. Carnivore damage is also present, although to a lesser extent, and suggests that fox- and wolf-sized carnivores, perhaps even dogs, gained secondary access by exploiting human garbage. Evidence for the transport of reindeer limbs, osseous artifacts, and other remnants of material culture indicates hunter-gatherers used P6 for habitation and the secondary processing of faunal remains, especially butchery, marrow extraction, and tool production. Overall, our results support prior interpretations of the site as a fall-winter aggregation camp and provide new information on human subsistence practices, the role of carnivores, and the use of space by Magdalenian people.

**Acknowledgements:** We would like to thank the Landesamt für Denkmalpflege, Regierungspräsidium Stuttgart for access to the materials (Simon Trixl, Yvonne Tafelmaier, Dirk Krausse), Gerd Albrecht and Hubert Berke for insight on the excavations and the faunal assemblage, and the Zooarchaeology working group in Tübingen (Keiko Kitagawa, Angel Blanco-Lapaz, Susanne Münzel, Gillian Wong, Elisa Luzi, Chris Baumann, and Siah Beattie) alongside other colleagues (Benjamin Schürch, Svenja Schray, Rudolf Walter, and Teresa Steele) for their advice and support.

# Examining Niche Partitioning of Extinct Hyaenid Species in Non-Analog Pleistocene Ecosystems

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Early Pleistocene ecosystems in eastern Africa are increasingly recognized as functionally non-analog in part due to the exceptionally high richness of large carnivores. One possible explanation for elevated richness is that it is a consequence of niche partitioning, such that greater niche differentiation would manifest as greater morphological divergence in extinct species as compared to extant species. The Pleistocene Koobi Fora Formation in eastern Africa provides an ideal testing ground for this question due to its well-dated record and presence of multiple carnivoran species in each member. Here, we examine niche partitioning between hyaenid species at Koobi Fora through 3D geometric morphometric analyses. The fossil hyaenid species sampled are *Crocuta ultra, Crocuta dietrichi, Hyaena makapani, Hyaena hyaena,* and *Parahyaena sp.* Extant species included in the analysis are *Crocuta crocuta, Hyaena hyaena, Parahyaena brunnea,* and *Proteles cristatus*. Cranial and postcranial bones were 3D scanned from the National Museum of Natural History in Washington, DC and the National Museums of Kenya in Nairobi to assess the prey procurement strategy of these extinct species. Our results show that extinct hyaenid species from Koobi Fora are morphologically most similar to their most closely related extant congeners, not morphologically distinct as we would expect if these hyaenids had a greater degree of niche partitioning. On the basis of ecomorphology, we infer that niche partitioning between fossil hyaenids within different Koobi Fora members could have looked similar to niche partitioning between extant hyaenid species in modern African ecosystems. These findings do not support the idea of increased carnivoran niche partitioning in Pleistocene ecosystems, meaning that the high carnivoran richness seen in those ecosystems may be due to other causes. Building on recent paleoecological work, we propose that higher primary productivity facilitated the co-existence of a greater number of hyaenid species relative to the present.

**Acknowledgements:** The authors would like to thank the Department of Mammalogy, especially John Ososky and Darrin Lunde, at the National Museum of Natural History and the Department of Paleontology, especially Emmanuel Ndiema and Samuel Muteti, at the National Museums of Kenya in Nairobi for the opportunity to collect data at their institutions. The authors would also like to thank Dr. Margaret Lewis for thoughtful feedback in the early stages of this project. This work was supported by the NSF (Award 2039759) and the Global Change and Sustainability Center at the University of Utah.

# Earliest Evidence of Artificial Cranial Modification in Epigravettian Arene Candide 12 (12000 BP)

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The cranium of AC12, recovered from the Final Epigravettian levels of Arene Candide cave (ca. 12,900–11,600 cal BP), is a crucial archaeological find that may provide insights into the antiquity of artificial cranial modification (ACM) practices. Piero Messeri's 1979 restoration of the fragmented material suggested a "circular oblique" type of ACM, but Formicola and Scarsini later questioned the evidence supporting ACM in AC12, suggesting premature cranial synostosis. This study takes a virtual anthropology approach to address the ACM question in AC12. A medical CT-scan of the cranium underwent virtual reconstruction through segmentation and semiautomatic realignment of bone fragments. The reconstruction, executed four times by different users, was compared with relevant reference samples, including 18 Paleolithic and Neolithic Italian individuals, 18 artificially modified skulls, and 9 pathological skulls (different cranial synostosis) from the Museum of Anthropology of Florence. To quantify cranial shape, 20 landmarks and 139 semilandmarks were applied. A first analysis employed only landmark configuration, while a second integrated the additional 139 surface semilandmarks. Geometric morphometric methods, encompassing a sliding procedure, generalized Procrustes analysis, and principal component analysis (PCA), were employed to investigate and visualize morphological variations. Total Procrustes distances and Canonical variate analysis (CVA) were utilized to explore AC12 groups' affinities. Results from PCA and CVA consistently position different AC12 reconstructions closer to or within the cluster of specimens with ACM. Classification results align all reconstructions with the ACM group. Total Procrustes distance indicates that AC12 shares closer morphology with ACM individuals than other penecontemporaneous individuals from Italy. These results are compatible with ACM being practiced in Europe during the final Paleolithic. Furthermore, AC12 would represent the earliest known evidence of ACM in the European archeological record, underscoring its pivotal role in unraveling the antiquity, evolution, and geographical distribution of this cultural practice.

**Acknowledgements:** T.M. is supported by Regione Toscana and Sistema Museale di Ateneo (Project name: DiVInA, grant: UNIFI_FSC2022). I.D. is supported by DM247 2022 MUR Italy Investment 1.2 "Funding projects presented by young researchers," grant number MCSA_0000035, project "IEPDA."

# How Did Middle Stone Age Humans Heat-Treat Silcrete at Pinnacle Point 13B Approximately 162,000 Years Ago?

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The heat treatment of silcrete at Pinnacle Point Cave 13B (PP13B) in South Africa ~162,000 years ago (ka) represents the earliest evidence for humans using fire to improve the quality of lithic tool-stone (Brown et al. 2009). Researchers have argued that heat treatment requires analogical reasoning, which is a feature of complex cognition (Wadley and Prinsloo 2014). However, this is debated (Schmidt 2016). The relevance of heat treatment to arguments of cognition are dependent on which method of heat treatment was utilized by Middle Stone Age (MSA) humans, but we currently lack well-established approaches to identify this in the archaeological record. Here, we present a new quantitative approach to distinguish three methods of lithic heat treatment that vary in their technological complexity: (1) the direct method, (2) the ember method, and (3) the sand-bath method. To do this, we combine predictive modeling with quantitative color measurements (Murray et al. 2022), which have been shown to accurately classify unheated and heated silcrete. Specifically, we trained a random forest machine learning algorithm on an experimental reference dataset of unheated silcrete and silcrete heated using each method of treatment. Currently, the model can distinguish method of heat treatment with an overall accuracy of ~92%. Next, we applied this model to silcrete artifacts at PP13B to determine what method of heat treatment was used over time. Our preliminary results show that the ember method was primarily used to heat-treat silcrete at PP13B, but a significant portion of artifacts were heat-treated using the sand-bath method, particularly in the earlier layers. This suggests that multiple strategies of heat treatment were utilized in the same layers. This research has implications for understanding when and in what context lithic heat treatment technology arose, which can help shed light on debates regarding the emergence of advanced cognition.

**Acknowledgements:** We thank the MAPCRM crew for their help with curating and pulling artifacts for analysis. This work is supported by the National Science Foundation (DDRIG Award #2321951 to JKM and CWM) and the Society for Archaeological Sciences Student and ECR Research Support Award.

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# Human Adaptation to Different Altitudes Through Time and Climatic Changes (HUMA)

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The evolution of *Homo sapiens* has always benefited from its ability to adapt to the most diverse environments. The subject of the adaptation of human groups to the environment has been of interest to scholars, whose attention is often turned to cases of adaptation to environments with extreme conditions and to the so-called ecological niches. However, little attention has been given to the choice of human groups to occupy extremely different environments (high mountains, higher than 2000 meters asl vs lowlands) and how high-altitude settlements relate to the lowland sites in the framework of the land management. This is particularly the case of the Finale Pleistocene to Mid-Holocene period in the Horn of Africa. The project HUMA is exploring the contribution of a multidisciplinary and integrated approach to the understanding of human adaptation to the different environments in the Later Stone Age of the Horn of Africa by integrating the most up-to-date approaches in lithic techno-functional analysis with organic and inorganic residues analysis on lithic artifacts and dental calculus analysis. Focusing on archaeological sites from Ethiopian highlands (Beefa Cave, a site discovered in 2019) and Somali highlands and plains, this paper will show the role played by the climate in the development of the cultural traits and how environmental factors may have fostered specific adaptations to different ecological niches and encouraged seasonal use of them.

**Acknowledgements:** University of Firenze (Italy); University of Connecticut; Italo-Spanish Research Project at Melka Kunture and Baltchit (Ethiopia); and, Ethiopian Heritage Authority (EHA).

## Taphonomy of a Seasonal Riverine Habitat: The First Year of the Zambia Rift Valley Research Project

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The Luangwa River in Zambia is one of the last major undammed rivers in Africa. For more than 700km, it flows unimpeded through a northeast–southwest oriented valley that is a southern extension of the Eastern African Rift System. Major central African river valleys would have provided biogeographical connections for ancient hominins and other mammalian groups, offering dispersal corridors into and across regions with variable environments. The Luangwa Valley is thus an important potential analogue for understanding ecosystems associated with human evolution. Here, we report the results of taphonomic investigations of the Luangwa mammalian community in South Luangwa National Park by the Zambia Rift Valley Research Project (ZRVRP). Following the skeletal survey methods of Behrensmeyer, in 2023 the ZRVRP initiated the first systematic taphonomy/bone walk survey sampling a seasonal riverine habitat in Africa. We also initiated an isotopic investigation of modern and ancient mammals living in South Luangwa. During our initial season, we surveyed floodplain, woodland, and grassland habitats and collected both fossil and modern materials. Preliminary results suggest that across habitats, skeletal elements were most often preserved from large taxa (size III or IV). In habitats with less tree cover, skeletal elements from size II animals were recovered, perhaps reflecting selective predation by smaller-bodied predators. Across size classes and habitats, we most often recovered dense elements that are likely to be preserved, such as vertebral bodies, horncores, pelves, carpals, and tarsals. These data suggest that taphonomic analyses of South Luangwa communities will contribute to hypotheses about how hominins and other mammals used different habitats within a seasonal riverine environment through time.

**Acknowledgements:** Earthwatch Institute and the American Philosophical Society.

## Late Pleistocene and Early Holocene Cultural Landscapes of Northern Butana in the Sahel of Sudan

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As the ecoclimatic transition between the Saharan Desert and the Sudanian savanna, the Sahel of Sudan is undeniably of great significance for understanding human adaptation, cultural evolution, and processes of transition from hunter-gatherer to agro-pastoral lifeways in the early prehistory of this part of Africa. This is attested by the quantity of sites documented over the past eight decades in this zone, especially considering that most field explorations so far were of non-systematic character. Here we present the results of our survey and test excavations in a landscape in northern Butana between the Nile Valley (between the 5th and the 6th cataracts) and Atbara River in central-east Sudan. We carried out field seasons in 2017 and 2022 with the specific objective of understanding the human landscape use during the Late Pleistocene within the context of diversity of this behavior across different ecoregions of northeastern Africa. We recorded 90 new open-air archaeological locations, including high-density stone artifact and raw material (mostly Hudi chert and quartzite) places and stratified habitation sites, from the earlier MSA to the early Neolithic. More than half of the explored locations are of the MSA technological character with abundance of Levallois and blade technological components. We will summarize the landscape context and technological characteristics of this record, focusing more closely on the MSA location NB-73, and try to place these results into the broader regional context of the long-term human behavioral evolution.

**Acknowledgements:** This research has been funded by Leakey Foundation.

## A Quantitative Analysis of the Micromorphology of Marks on Bone Retouchers Used to Sharpen Lithics

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Bone retouchers, commonly found in the Middle and Upper Paleolithic of Europe, are claimed to be a toolkit for post-Acheulean hominins. Nevertheless, uncertainties persist regarding when and where this technology flourished, leading to debates on whether it was deliberately selected for resharpening and shaping stone tools or opportunistically utilized. While traditionally associated with Middle to Upper Paleolithic behavior, some suggest a connection with early Pleistocene hominins implicating the origins of the tech-

nology as having great antiquity. Even though bone tool technology is known from the Early Stone Age of Africa, evidence for bone retouchers has not been reported. This may be in part due to similarity between the morphology of marks found on bone retouchers and those produced by other processes, including carnivore chewing and hominin butchery. Identifying the origin of this technology is important because it signifies a significant behavioral change in hominin evolution, but the qualitative approaches currently in use limit our ability to do so. Here, we report the results of an actualistic experiment where partially weathered equid bones were used to sharpen raw materials from Olduvai Gorge, Tanzania. The resulting damage to the bones was molded and subsequently scanned with an S-Neox non-contact profiler to create high-resolution 3-D models of individual marks, which were measured and compared with actualistic samples of carnivore tooth marks and human butchery marks. Results show that quantitative methods can effectively distinguish between the compared mark types.

## $^{230}$Th/U Burial Dating of Australian Megafaunal Eggshells

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Available data indicate that human arrival in Australia and the extinction of many megafauna ~65–45 thousand years ago (ka) overlapped, but examining the timing of these events and the duration between them have proved challenging. The large flightless bird *Genyornis newtoni* overlapped with human presence on the continent, as evidenced by pattern-burnt eggshell fragments and by unmodified fragments at stratified anthropogenic deposits, but the timing of these interactions and the role of humans in the regional extirpation and eventual extinction of *Genyornis* are not well resolved, in part because they lie near the effective limit of $^{14}$C dating. We show that $^{230}$Th/U burial dating of *Genyornis* and emu eggshell is a promising new approach to this problem. $^{230}$Th/U burial dating has been successfully applied to ostrich eggshell in African archaeological contexts (Niespolo et al. 2021; Sharp et al. 2019). To extend and test the technique on similar but distinct *Genyornis* and emu eggshells, we have: 1) measured U and common Th ($^{232}$Th) profiles across modern and ancient eggshells via laser ablation ICP-MS (LA-ICP-MS), and 2) measured via solution ICP-MS $^{230}$Th/U ages of two subsamples selectively abraded from optimal positions within each eggshell. Precise (±1-4%, 2s) $^{230}$Th/U burial ages of ~25 to 50 ka BP of well-preserved emu eggshells are in close agreement with $^{14}$C ages of the same sample. $^{14}$C and $^{230}$Th/U burial ages of the youngest, well-preserved *Genyornis* eggshells near the $^{14}$C limit also agree. These results are consistent with early, rapid uptake of U upon burial followed by closed evolution of the U-Th system in eggshells. Thin section petrography, LA-ICP-MS results, and $^{230}$Th/U isotope data inform on the preservation and suitability of samples for $^{230}$Th/U burial dating, providing a promising new way to date the extinction of *Genyornis* and the timing of human arrival to Australia.

**Acknowledgements:** We thank the NSF Archeometry program (BCS-2211894), the Leakey Foundation, and the Center for Evolutionary Science (Caltech) for support. EMN was supported by the Barr Postdoctoral Fellowship (Caltech) for a portion of this work.

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## Different Migratory and Dietary Responses to Seasonality in Last Glacial Period Versus Present-Day Kenyan Large Herbivores

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Plant forage availability for many African herbivores is driven in part by precipitation seasonality, with high-quality grass peaking in abundance during rainy seasons and declining in quality during dry seasons. In present-day African savannas, large herbivores typically navigate seasonal bottlenecks in resource availability through either diet-switching (e.g., consuming more dicots during the dry season) or migrating to follow the availability of preferred resources. However, nothing is known of this behavior in prehistory. Using serially sampled stable carbon and strontium isotopes from Kenyan bovid and equid teeth from the Last Glacial Period (LGP), we evaluate the diet and water intake of 18 herbivore species and compare the extent to which diet-switching and migration were used as responses to seasonality between the LGP and present. We find a high $C_4$ grass component in the diet of nearly all species, including some browsers and mixed-feeders. Additionally, we find no links between intra-annual variation in diet and migration, indicating that the modern tradeoff between these behaviors is potentially recent in origin. Whereas today, African mixed-feeders tend to switch diets seasonally, and grazers tend to migrate, most individuals in our LGP study have stable, grass-dominated diets and no evidence for migration. This change may be linked to climate changes in eastern Africa through the Late Quaternary—cooler temperatures in the LGP would have decreased evapotranspiration, allowing for greater availability of palatable grasses even during dry seasons. These results establish a revised paleoecology of LGP herbivore communities in eastern Africa and alter our interpretation of the ecosystems in which key phases of human evolution are thought to have occurred, and the extent to which we can rely on modern analogs to interpret them.

## Isotopic Niche Space: A Novel Approach to Assess Hominin and Faunal Niche Dynamics at the Site of Laetoli, Tanzania

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Stable isotopes have been used to characterize the dietary and bioclimatic dimensions of early hominin niches. Isotopic niche space offers a way to investigate how these paleoecological factors interact through spatial statistical analysis of bivariate plots. This method can quantify the total breadth and overlap of different faunal niches while also controlling for sample sizes in fossil assemblages associated with early hominins. Using isotope space measures, we construct ecological niches for mammals from the Upper Laetoli Beds (~3.6–3.85 Ma) based on published carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) mammal tooth enamel isotopes. The fauna were analyzed at a family level and included Bovidae, Equidae, Giraffidae, Rhinocertidae, and Suidae. Due to sample size constraints (minimum n=10), the samples span the entire site assemblage. The isotopic niches of each of the faunal groups were analyzed for total area and percentage overlap with all other pairs. Analysis revealed wide variation in $\delta^{18}O$ values among families, with most overlap of niche space in the $\delta^{13}C$ dimension. We find the wide range of $\delta^{18}O$ among Giraffa is not a reflection of species difference and is a broader family-level trend. Rhinocerotidae and Bovidae both exhibit wide $\delta^{13}C$ spread and have 88% overlap, possibly reflecting a shared isotopic niche. While this method provides insights into niche reconstructions, uncertainties related to assessing fossil abundance, determining taxonomic resolution, and developing a detailed chronostratigraphic framework potentially limits this technique. Further analysis of hominin niches at Laetoli requires tighter resolution of faunal composition and depositional environment, ideally at a site or member level. This would require targeted faunal isotope sampling in a site with a clear geological framework, including the potential sampling for hominin isotopes. Laetoli is primed for this type of analysis that, in combination with ongoing fieldwork, can provide additional insights into hominin niche partitioning.

## Paleoecology of the Saber-Toothed Felid *Lokotunjailurus emageritus* from Lothagam (Turkana Basin, Kenya)

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Saber-tooth felids were apex predators in eastern Africa's Plio-Pleistocene carnivore guild, but their paleoecology and position within the carnivore guild in earlier time periods remains less understood. Here, we investigate the paleoecology of the late Miocene saber-tooth felid *Lokotunjailurus emageritus* from Lothagam (Turkana Basin, Kenya) using postcranial elements from the exceptionally well-preserved holotype skeleton (KNM-LT 26178). We collected three-dimensional surface scans of KNM-LT 26178 and used them to score discrete postcranial characters, measure limb indices, and landmark joint surfaces for geometric morphometric analyses. These data were compared with other carnivoran species (n=23), including extant felids, canids, and hyaenids, and extinct eastern African saber-tooth felids (*Dinofelis*, *Homotherium*, *Megantereon*). This comparative dataset allowed us to distinguish various hunting modes (prey grappling; pursuit; non-prey grappling, carcass carrying) and locomotion (arboreal, scansorial, terrestrial, cursorial) using hierarchical clustering and ordination methods. Our analyses suggest that *L. emageritus* likely favored a closed- to mixed- habitat, similar to the habitats of extant medium to large-sized felids. Notably, *L. emageritus* clusters with extant felids that have well-developed climbing and/or prey grappling adaptations (e.g., *Panthera onca*, *P. pardus*, *P. tigris*, and *Neofelis nebulosa*), such as an elongated ulnar olecranon process and a high biceps brachii leverage index. Compared to other extinct saber-toothed felids, *L. emageritus* is most similar morphologically to *Dinofelis* spp. and *Megantereon* spp., suggesting similar ecological niches characterized by prey grappling hunting techniques with scansorial locomotion. In contrast, *Homotherium* spp. cluster with species characterized by cursorial locomotion that lack prey grappling tendencies (e.g., *Acinonyx jubatus*, *Canis lupus*). Overall, this quantitative analysis improves our understanding of the paleoecology of *L. emageritus* and other extinct saber-tooth taxa, shedding light on the faunal interactions in eastern Africa during the late Miocene.

## The Relationship Between Distal Femur Morphology and the Evolutionary History of Locomotion

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Primate knee anatomy reflects locomotor differences due to the different forces and loads placed upon the knee by distinct locomotor modes used by individuals, along with inherited morphology associated with ancestral locomotion for a given species. A locomotor shift occurs when ancestral locomotion differs from present-day locomotion, which may lead external shape morphology to more strongly reflect ancestral rather than present-day locomotion. This study aims to determine whether external morphology of the distal femur changes similarly across primate species in response to specific locomotor shifts. The sample consists of wild-caught adult males and females for 200 specimens across 50 species, with at least one male and female per species. Landmarks, curved semilandmarks, and surface semilandmarks were placed on articular surfaces using Checkpoint from Stratovan. Principal components (PCA)

and linear discriminant function with leave-one-out cross-validation (DFA) analyses were run on the complete landmark dataset. A marginal ancestral state reconstruction was generated for all extant haplorhines in 10k Trees for ancestral locomotion. Three locomotor mode (arboreal, semi-arboreal, terrestrial) and locomotor shift (arboreal, terrestrial, unchanged) categories were used as the grouping variables for the DFA. PCA and DFA results are as expected with group separations/misclassifications primarily driven by arboreal/semi-arboreal and arboreal/unchanged groups, with fewer misclassifications occurring due to terrestrial locomotor mode or shift (71% locomotor mode correct classification; 68% locomotor shift correct classification). These results suggest that both present-day locomotor mode and locomotor shifts can be correctly identified more often than not using external morphology, indicating that present-day morphology can be used to interpret ancestral locomotion as well an evolutionary shift in locomotion from the ancestral condition. Higher misclassification rates in arboreal/semi-arboreal and arboreal/unchanged groups are most likely due to higher similarity in locomotion among those groups compared to terrestrial locomotion.

**Acknowledgements:** I would like to thank the American Museum of Natural History, Adam Gordon, and Tim Ryan and Simone Sukhdeo for their access to collections and data used in this project.

## Laminae-Facet Angle Differences on Hominid Cervical Vertebrae

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The cervical spine is of great importance to understand posture and locomotor pattern of ancient species. Several differences have been found in cervical vertebrae morphology of Primates (Nalley and Grider-Potter 2015), where the spinous process length and orientation together with the superior articular facets orientation are the most variable features (Arlegi et al. 2017). These differences are possibly related to different cervical lordosis and head posture. However, both the superior articular facet and the spinous process orientations are measured taking as reference the superior margin of the vertebral body. As the cervical fossil record is scarce, vertebral body is not always preserved and other measurements are necessary to understand some cervical remains. With this in mind we set a new measurement—the angle (in degrees) between the superior articular facet and the superior margin of the laminae, in lateral view. Laminae-facet orientation of a total of 92 cervical vertebrae belonging to different hominid species has been measured—30 *Homo sapiens*, 30 *Pan troglodytes*, 23 Neanderthals, 5 early *Homo* (from Dmanisi, Gran Dolina, and the Nariokotome boy) and 4 australopithecines (from MH1, MH2 and AL333). Chimpanzees show the most coronal orientation (137º), followed by the australopithecines (141º) and the early *Homo* individuals (142º). Neanderthals (159º) and modern humans (155º) show more cranially oriented superior articular facets and are significantly different to the other species. Even so, there is a difference between Neanderthals and modern humans—while the latter show more coronally oriented C3 and C7, Neanderthals show that pattern only in C3, similar to chimpanzees. That could be related to the proposed lower cervical lordosis in this species (Gómez-Olivencia et al. 2013). The similarity of our results to that obtained by Arlegi et al. (2017) show the potential of studying the superior articular facets orientation via this measurement, when the vertebral body of a fossil cervical vertebrae is missing.

**Acknowledgements:** Grants PID2020-115854GB-I00 to M.B. and PTA2020-018205-I to C.A.P. are funded by MCIN/AEI/10.13039/501100011033 of the Spanish Ministry of Science and Innovation and the European Union.

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## The Taphononic History of the Neandertals from Krapina

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The assemblage from the Krapina rockshelter, Croatia has been the focus of intensive analysis over the last 125 years. While Gorjanović-Kramberger took detailed notes during excavations from 1899–1905, relatively general descriptions of the stratigraphic associations of the Neandertals, fauna, and cultural materials encouraged various and competing interpretations of the primary agents of assemblage accumulation. Cut marks appear on both the Neandertal and faunal remains. Although cannibalism often is invoked to explain the marks on the Neandertals, some hypothesize their location, pattern, and density represents a secondary burial practice instead. Still others suggest that natural geological processes like rockfall are responsible. Here we report on renewed efforts to understand the origin of the Krapina assemblage based on results of a systematic taphonomic analysis of the assemblage. In October of 2022, we visited the Croatian Natural History Museum to conduct a comprehensive taphonomic analysis of all 723 Neanderthal fossils in the collection excluding teeth. The presence of both stone tool cut marks and hammerstone percussion marks indicate Neanderthals were cannibalized for both flesh and marrow, while carnivore tooth marks and epiphyseal destruction suggest the processed skeletons were abandoned on the surface and accessible to scavengers. Peeling on ribs was also observed suggesting some tooth marks may have been left behind by Neanderthal consumption. The results of this study have ruled out rockfall as the primary agent of fragmentation in the assemblage and strongly suggest the remains were cannibalized rather than processed for burial resolving two of the long-standing

debates about the formation of the assemblage. However, ritual cannibalism cannot be refuted or supported by our results due to equifinality in their relative taphonomic signatures.

## Incorporating Citizen Science in Archaeological Research, the Case Study of the Early Occupation of Sicily (EOS) Project

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The oldest uncontroversial evidence for hunter-gatherer arrival on a Mediterranean island is in Sicily at ~17 kya. It is widely accepted that humans entered the island through a short-lived land bridge, that connected the island to Italy between 21.5 and 20 kya, shortly after the Last Glacial Maximum (LGM ~26.5–19 kya), when portions of coastal landscape were exposed by lower sea levels. However, our understanding of the timing of human arrival and occupation patterns on Sicily relies on a limited amount of scientifically researched sites, concentrated on the northern shore of the island. The lack of research on the rest of the island, including its submerged landscapes, hinders our understanding of migratory and occupation patterns. The main goal of EOS is to trace human migration and to contextualize occupation across Sicily, investigating vast areas of landscapes virtually unexplored for Paleolithic remains, both on land and underwater. Local knowledge is invaluable when surveying large extensions of landscapes. EOS is a collaborative project that incorporates international and Sicilian researchers, and local stakeholders. Together we have found >30 sites since 2022, many of which were otherwise unrecorded by professional archaeologists. In 2023 we organized a workshop for Navy and recreational divers and speleologists to train citizen scientists on identifying stone tools, fossils, and paleosols on land and underwater. Thanks to collaborations with these citizen scientists and other local stakeholders we identified 3 partially submerged caves with mid to late Pleistocene fossils, and 2 submerged paleosols. On land, we located two flint outcrops, reviewed two private collections, and catalogued 5 new sites on the southern shore. Our collaboration with local researchers and stakeholders allows us to survey vast extension of landscapes, while significantly increasing visibility and public understanding of human evolution, Paleolithic archaeology, migration, and sustainability in the Mediterranean.

**Acknowledgements:** We acknowledge the local communities of Augusta, Brucoli, Pedagaggi, and Ragusa that have hosted us and shared with us their knowledge of the landscape and local history. In particular we would like to thank Mr. Russo and Mr. Patania. We thank our collaborators the Italian Navy, in particular, their Admiral and diving unit of the Comando Marittimo Sicilia, the Paleontology Museum of the University of Catania, Ceratonia Geophisics, and the Archeoclub section of Augusta. Funding for this project was provided by grants to Patania from the Leakey Foundation and the Rust Family Foundation, to Tryon from the University of Connecticut College of Liberal Arts and Sciences Summer Research Initiative, to Carroll from the Center for Environmental Sciences and Engineering and the Institute of the Environment at the University of Connecticut, and to Garnette from the Newman Exploration Travel Fund and the George R. Throop Endowment at Washington University in St. Louis.

## Hallucal Proximal Phalanx Robusticity in Chimpanzees, Humans, and Fossil Hominins

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Humans and chimpanzees have different bipedal foot biomechanics. One defining characteristic of humans is the lateral-to-medial shift in the center of pressure (COP) from midstance into toe-off. At midstance, a larger portion of weight is supported by the lateral forefoot, typically under the metatarsals. At toe-off, more of the weight is supported by the hallucal phalanges as the hallux is the last toe to leave the ground. In chimpanzees, COP during stance is more variable, but tends to be centralized under the foot, with more weight supported by the lateral phalanges rather than the hallux at toe-off. When human-like greater hallucal weight-support at toe-off evolved is unclear despite morphological studies of chimpanzee, human, and fossil hominin hallucal metatarsals (Mt1). Because hallucal phalanges, and not the Mt1, comes off the ground last in humans, investigating robusticity of the former in chimpanzees and hominins may provide new insight into the evolution of hallucal toe-off biomechanics. We quantified from μCT/CT images midshaft polar moment of area (PMA), a proxy for bending/torsional strength, of the hallucal proximal phalanx (HPP) in chimpanzees (n=44) and humans (n=35). When scaled to bone length, human HPPs are significantly more robust ($p<0.05$). We then used published AP and ML midshaft diameters to estimate PMA, modeled as a solid beam (sPMA), to assess relative HPP robusticity in fossil hominins. This approach was validated by a significant correlation ($p<0.05$) between PMA and sPMA in both humans ($r^2=0.72$) and chimpanzees (r2=0.98); sPMA from external diameters only overestimates true PMA by 2–3% in both groups. Notably, the Burtele HPP (BRT-VP-2/73g) is weak like chimpanzees, while HPPs of *Homo neanderthalensis* and *H. antecessor* (ADT6-30/31) display strength comparable to humans. HPPs of *H. naledi* (U.W.101-082/1452) and *H. floresiensis* (LB10), however, are weaker than humans, suggesting diverse hallucal toe-off biomechanics among *Homo* species in the Pleistocene.

# Using Drone Survey to Map Stratigraphy and Hominin Activity Patterns at Olduvai Gorge

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Almost 100 years since it was first excavated, Olduvai Gorge, Tanzania, has continued to provide a wealth of paleontological, archaeological, and geological information crucial to understanding the evolution of our lineage. The geographically and temporally extensive deposits sample almost two million years of human evolution, allowing for large-scale questions to be investigated regarding hominin behavioral ecology, land-use, and response to environmental changes. New research methods have been able to expand our current knowledge and allow for new approaches to existing datasets. Our team recently conducted an extensive unmanned aerial vehicle ("drone") photogrammetric survey of Olduvai Gorge. The high-resolution imagery captured during this survey has been used to map the topography and extent of stratigraphic exposures at the site, in order to investigate how these may bias our understandings of the spatial distribution of hominin activity patterns at different scales. We present preliminary results showing how drone-based imagery and GIS can be used to analyze and compare the availability of fossiliferous exposures, excavation locations, and the pattern of hominin activities. Our results demonstrate the importance of taking exposure availability and excavation history into account when interpreting the pattern of archaeological localities.

**Acknowledgements:** We would like to thank the Colorado State University (CSU) Department of Anthropology and Geography and the CSU Africa Center for providing funding for this project. We would also like to thank the Ngorongoro Conservation Area Authority and the Antiquities Division of the Tanzanian Ministry of Culture and Tourism for allowing us to conduct this research. Deepest appreciation goes out to everyone who worked on the drone surveys, especially Rogers Shitobelo, JJ, Malita, and Justin. Additional sincere thank yous to Connie Fellman, Claudia Johnson, and all of the staff, crew, and drivers of the 2023 Olduvai research camp.

# Modeling the Influence of Volcanic Processes on Speciation and its Implications for Hominin Evolution

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Research on East African Rift System (EARS) processes and hominin evolution has primarily focused on the increase in topographic complexity and the influence on regional climate patterns; however, the impact of EARS-related volcanic processes is less understood. This is an important factor to investigate as occupation in unstable volcanic habitats has been suggested to lead to rapid speciation through stress-induced transposition. Volcanic uplift and eruptive material can also isolate populations, blocking gene flow and/or forming genetic bottlenecks. We utilize multi-agent based modeling to investigate the relationship between EARS-related volcanic processes and speciation and how different eruptive styles/compositions affect speciation rates. The base landscape used in the models remains constant and features a simplified graben with a volcanic highland on the eastern shoulder. We populated the landscape with agents, or individuals of a theoretical species, that can move and interact with each other and the landscape allowing for reproduction, dispersal, and gene flow. When agents interact and reproduce, the offspring have a hybridization of both genomes as well as the potential to change aspects of the genome through mutation. The models ran before, during, and after eruptive events with each iteration having variations in eruption type, composition, duration, and total number of eruptions. Agents are impacted by the eruptions through stress-induced mutations, forming new genetic variations, and by the removal agents, decreasing genetic diversity of the population. The eruptive material can also form physical barriers to gene flow. We found that speciation rates differed between explosive and effusive eruptions and that multiple eruptive events lead to more rapid speciation compared to single events as gene flow is further reduced. This may have implications for hominin evolution as the increase in taxonomic diversity coincides with wide-spread active volcanism from ~5–2 Ma and after ~1.6 Ma, but this would need to be further investigated.

**Acknowledgements:** Indiana University - Bloomington; The Leakey Foundation.

# Global Review of Early Childhood Graves 20,000 to 9,000 Years Ago and Their Cultural Implications

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The field of anthropology has largely been focused on telling the male narrative of the human past; this conversation has shifted recently as work in the archaeology of children and women has gained traction. Specifically, there is a lack of research in archaeology focused on early childhood from 20,000 to 9,000 years ago due in part to research bias, preservation status, and inconsistencies in the study of childhood. This time period is an important transition from the Late Pleistocene to the Early Holocene, where changing patterns in human behavior can reveal shifting cultural and biological strategies in response to environmental and social factors. As the

mechanism in which evolutionary fitness and genes are passed on, children are critical to the success of human populations, therefore the treatment of children in death can provide insight into past ideologies about personhood and reveal notions of agency and investment in individuals who died young. Inconsistencies in the literature surrounding the discussion of non-adults and children, specifically a lack of consensus regarding early childhood age categories, makes comparing the burials of young children for the sake of revealing patterns of behavior difficult. The intention of this project was to make those age categories clear, to review the literature for burials of individuals from around birth to 5 years old and catalogue any associated artifacts and funerary behaviors, to discuss what those burials reveal about past human culture, and, finally, to critique past research to pave the way for more responsible and comprehensive anthropology in the future.

**Acknowledgements:** I'd like to thank my M.A. thesis committee at CU Denver, Jaimie Hodgkins, Tammy Stone, and Anna Warrener for their support of this project.

## Oldowan Occurrences on the Homa Peninsula, Kenya

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The Oldowan Industry (ca. 2.6 – ca. 1.7 million years ago (mya) is the first geographically widespread and temporally long-lasting lithic technology in the archaeological record. Three localities have been found on the Homa Peninsula, southwestern Kenya, that cover much of the temporal extent of the Oldowan: Nyayanga (3.032–2.595 mya), Kanjera South (ca. 2 mya) and Sare-Abururu (ca. 1.7 mya). First, Nyayanga has yielded some of the oldest Oldowan occurrences in a grazer-dominated ecosystem in proximity to both a stream channel and a freshwater spring. Several butchered partial hippopotamid skeletons have been excavated, one spatially associated with a *Paranthropus* molar. Tool use-wear and bone damage indicate plant and animal tissue processing involving both pounding and cutting. Second, Kanjera South is the most intensively studied locality and has yielded evidence of habitual transport of high quality lithic raw materials. Oldowan hominins at Kanjera frequently had early access, likely through hunting, to small juvenile bovids, and mixed access to medium-sized bovids. The record of hominin activities is consistent through three meters of section, suggesting persistent carnivory over centuries in a grazer- and grass-dominated ecosystem. Third, Sare-Abururu preserves evidence for a grassland-dominated paleolandscape extending over 2km, incised by a modern river. Unlike Nyayanga and Kanjera, Sare-Abururu has locally available high quality tool stone. Test squares over a 200m transect document a single high-density accumulation of artifacts, indicating a definite spatial focus of hominin discard activities. Lithic procurement and reduction patterns through time at these localities appear to reflect variation in local resource contexts rather than large-scale evolutionary changes in hominin cognition, energy budget, or mobility.

**Acknowledgements:** The authors thank the National Museums of Kenya and M. Gikungu, E. Ndiema, F.K. Manthi, and J. Mwangi for support. We acknowledge Kenya Government permission granted by the Ministry of Sports, Culture and the Arts (NACOSTI permit P/14/7709/701) and the National Museums of Kenya. Homa Peninsula Project fieldwork is carried out under the collaborative agreement between the National Museums of Kenya and the Smithsonian National Museum of Natural History. This work was supported by the National Science Foundation (grants DDIA#1836669 and #1327047), the L.S.B. Leakey Foundation, the Peter Buck Fund for Human Origins Research (Smithsonian Institution), William H. Donner Foundation (R.P., T.W.P.), and NERC CIAF Grant (9170- 0416).

## Hominin Occupation Site vs. Landscape: A Comparative Analysis of Hominin-Use Evidence on Faunal Remains in the Koobi Fora Region

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Understanding hominin access and use of the landscape are primary questions in paleoarchaeology. FxJj50, dated to 1.5 mya, has yielded substantial evidence regarding hominin occupation patterns, including 22 butchered carcasses, 10 cut-marked specimens, and approximately 1400 stone artifacts. After the site's initial excavation from 1977–1979, researchers concluded that FxJj50 is a hominin occupation site representing a range of grassland to woodland environments with close proximity to a water source. FxJj38, a raw material procurement site, was first excavated in 1974 after the discovery of specimens KMN-ER 1805 (*Homo habilis* cranium) and KMN-ER 1806 (*Paranthropus boisei* mandible). The site has yielded over 100 stone artifacts and 500 faunal specimens within a Plio-Pleistocene context (Isaac and Isaac 1997). This project aims to improve our understanding of hominin consumption patterns in the Koobi Fora region by conducting a comparative analysis of the density and modification of faunal remains found at FxJj50 to those of a non-occupied landscape 200m south of FxJj38NW. Faunal remains within 50m$^2$ boundaries at both locations were mapped using an RTK system, collected, identified, and examined for presence of hominin percussion and cut marks. A comparative analysis was conducted through chi square tests with a significance value of $p>0.05$. Evidence indicates differences in use between the sites and suggests that FxJj50 may

contain more layers of lithic and faunal remains than previously concluded. New evidence for hominin butchery at FxJj50 furthers our knowledge of hominin consumption patterns in the Koobi Fora region.

**Acknowledgements:** Funding: Partial funding provided by NSF Archaeology Grant #2018896. Dr. David R. Braun, Dr. Emmanuel K. Ndiema, Norah Brady, MacKenzie Pina, Koobi Fora Research and Training Program, The National Museums of Kenya.

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## Chewing Intensity of a Modern Spotted Hyena Modified Assemblage

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Documenting chewing damage in fossil assemblages' aids in identifying carnivores responsible for contributing to assemblages. A first step in such documentation is studying chewing damage inflicted by extant carnivores, with an aim towards identifying taxon-specific chewing damage patterns. Much of this research has focused on chewing damage by spotted hyenas, which have specific adaptations for bone crushing to access marrow within the bones of their prey. This project contributes to that body of work by applying a new method developed by Pobiner (Pobiner et al. 2020) to an assemblage created by Salvatore D. Capaldo in the 1990's. Intensity of chewing damage is quantified using a 5-stage scale. A chewing damage intensity score was assigned for skeletal elements and portions (0=no damage, 1=tooth marks only, 2=minimal chewing damage, 3=moderate chewing damage, and 4=severe chewing damage, fragmentation, or destruction). It was predicted that both skeletal element and spotted hyena specific adaptations would condition the intensity of chewing damage inflicted. This can be seen with the high average damage for nearly all long bones with high averages being: femur, humerus, tibia, radio-ulna, and metacarpal. Comparatively, ribs and scapulae are less intensely chewed.

**Acknowledgements:** Thank you to Dr. Pante, Dr. Capaldo, and Colorado State University for the creation and maintenance of the assemblage. Thank you to Dr. Pobiner for developing the semi-quantitative method and to Dr. Hodgkins for guidance throughout the project.

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## A Bio-Available Strontium Isoscape for the South Kenya Rift: Implications for Tracking Faunal Landscape Use

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The Olorgesailie Basin in the South Kenya Rift contains sediments dated to between 1.2 Ma – 499 ka and 320 – 36 Ka ago, preserving Acheulean and MSA archaeology. In eastern Africa, the MSA is primarily characterized by blade and microlithic technology, long distance trade, use of pigment, use of aquatic resources, and specialized hunting, which is a substantial technological shift from the large blade-based technology of the Acheulean. Previous research showed sixteen of the twenty-three taxa recovered from the Olorgesailie MSA strata are not found in the Acheulean levels, suggesting substantial mammal turnover. This widespread faunal turnover likely had cascading effects on the movement of local taxa, which could be investigated using strontium isotopes. This study presents a new bio-available isoscape of $^{87}Sr/^{86}Sr$ across the South Kenya Rift and Northern Tanzania. We used published water, vegetation, and enamel samples to interpolate strontium variation using empirical Bayesian kriging. Within 50km of Olorgesailie, strontium variation appears to be minimal. However, within 75–100km, strontium values increase substantially. There is a hotspot of high $^{87}Sr/^{86}Sr$ near Lake Manyara within the Serengeti Volcanic Grassland ecoregion. Our findings allow us to contextualize future work by relating strontium isotopes to landscape ecology around the Olorgesailie Basin and to better understand the relationship between faunal turnover and movement during the MSA.

## The Effect of Trait Redundancy on Parsimony-Inferred Tree Topologies from a Hominin Character Matrix

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Accurate hominin phylogenetics is challenged by the high proportion of incomplete fossil remains. Understanding what phylogenetic information (PI) is contained in those incomplete remains is crucial to improving the quality of paleoanthropological phylogenetics. Most hominin phylogenetic reconstructions are based on characters assumed to be phylogenetically informative (free from homoplasy) and mutually independent (with little to no overlap in the information described by those traits), but limited work has been done to test for these qualities. We quantified the degree of redundancy and PI in 107 discrete hominin craniodental and mandibular traits using three approaches: a) permutation of character values along the tips, b) removal of a character, and c) removal of groups of traits

by cranial bone. We used the Cladistic Information Content of each individual character to define the expected amount of PI before tree-building. Next, we permuted (a) or removed (b) each trait sequentially within the character matrix and constructed a test tree from the modified character matrix. We compared the topologies of the test trees to a baseline tree (constructed from the unmodified character matrix) and measured the effect of each change on the inferred topology using Robinson-Foulds distance. We also grouped traits (10 groups in total) by which bone they predominantly belong to (c) and either sequentially removed those groups or removed all other groups (such that the tree was only constructed from traits from a single bone) and compared those test trees to the baseline topology. We show that 62 of the 107 traits are redundant, 45 are uninformative, and no single bone provides enough PI to reliably place fragmentary fossils at either the species or genus levels. Our findings suggest that isolated and/or fragmentary remains are not informative for phylogenetic reconstruction and support only the inclusion of relatively complete specimens in phylogenetic analyses.

## Craniofacial Development, Variation and Sexual Dimorphism in Extant Great Apes

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Craniofacial features, ontogenetic changes, and inter-and intra-specific variation in extant great apes are commonly studied as comparative context for fossil hominins, not to shed light on the evolution and development of the respective species. Moreover, the extent and source of intraspecific variability of the commonly cited taxon-specific features—such as ontogenetic modification and sexual dimorphism—remain understudied. Here, we reevaluate the diagnostic craniofacial features and variability in extant great apes and identify when the species-specific features are established through ontogeny. To do this, we quantified craniofacial variation and sexual dimorphism using craniometric analysis collected mainly following Martin's protocol (60 measurements from one cranium and so far, *n*=174). Moreover, using 3D Geometric Morphometric analysis (GM; *n*=351), we examined the role of craniofacial allometric scaling and shape variation at different developmental stages. Our result shows that some cited taxonomically diagnostic features are variable (i.e., developmentally or functionally unstable) or sexually dimorphic. Ontogenetically, the diagnostic anatomical features are established in a piecemeal. While several of them are established in the neonates, others are seen by the time of M1 eruption or continuously transform until adulthood. Moreover, we noted a higher coefficient of variation within *Gorilla* than in *Pan*, and similarly, sexual dimorphism is much higher in *Gorilla* than in *Pan*—both at genus and species levels. GM-based evaluation of ontogenetic allometry among the great apes shows high size-related inter- and intra-specific variations mainly along the common growth trajectory to different size and shape ranges, save for orangutans, which show divergent growth patterns. In addition, we found non-allometric shape differences within African great apes. Overall, these data provide an insight into character polarity, growth, and development in extant great apes and its implication for fossil apes and early hominins.

**Acknowledgements:** This research is funded by the Leakey Foundation, the Wenner-Gren Foundation, the Centre National de la Recherche Scientifique (CNRS), and the University of Chicago.

## Comparing Dispersal Patterns of African Hominins in the Plio-Pleistocene

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Two models of hominin dispersal between eastern and southern Africa have previously been proposed: 1) a center of distribution in eastern Africa associated with peripatric speciation of new taxa, or 2) more consistent exchange between the two regions until dispersal corridors closed, resulting in allopatric speciation. In light of recent hominin discoveries in these regions, we reexamine both models using large mammal biogeography with fossil sites that are dated between ~4.8 Ma to ~1.9 Ma, focusing on *Australopithecus* and early *Homo* species. We analyze occurrences and ecological trait data (body size and diet) using cluster analysis and principal coordinates analysis. Modern communities are compared across Africa (n=206) and in a regional subset mimicking the restricted distribution of the fossil assemblages (n=73). We use the presence of unique mammals as a proxy for isolation. The modern and fossil regions that contain the largest numbers of unique mammals are northern and southern Africa. We also found that areas within eastern Africa (e.g., Turkana Basin, Laetoli, and Awash Valley) were isolated from one another between ~4.0 and ~2.8 Ma, supporting the presence of dispersal barriers at that time. After ~2.8 Ma, areas in eastern Africa began to share more taxa, suggesting that barriers were diminished or no longer present. Southern Africa likely has no known fossil localities before ~3.0 Ma, but from ~3.0 to ~1.9 Ma it is isolated from eastern and northern Africa. These results support the model of exchange between regions when corridors opened, with evidence of newly dispersed species in previously isolated areas. Notably, carnivores and insectivores were most widely dispersed in modern communities, but not in the fossil record; we discuss how these differences in trait representation may be affected by taphonomic processes rather than reflecting actual differences in the fossil record.

# Depositional and Cultural Contexts of Late Pleistocene *Homo sapiens* Fossils from Rabat-Temara Caves in Morocco

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Over the past sixty years, excavations of the caves of Rabat-Temara area in Morocco have recovered numerous human fossils from Middle and Later Stone Age deposits, with several of these being almost complete skulls. This makes this area extending only 10km along the Atlantic coast among the richest in the specimens of *Homo sapiens*, both in their early and late forms. Beside human fossils, El Harhoura 1, El Harhoura 2, El Mnasra, Dar Es-Soltan 2, and Contrebandiers have yielded an abundance and variety of material record of stone and bone tools, fauna, marine mollusks, *Tritia* and other shells, plant remains, and combustion features, attesting to intensive, albeit intermittent, use of this region from likely the later part of the MIS 6 into the Holocene. However, these excavations in the past have been conducted by different research teams and even though these caves share the same or similar material culture, stratigraphy, and formation history of their deposits, apart from chronology (e.g., Ben Arous et al. 2020, 2022; Jacobs et al. 2012; Schwenninger et al. 2010) there has been a lack of comparative studies from the regional perspective (see Bouzouggar et al. 2020; Nespoulet et al. 2008). In 2022, we renewed the excavations of Contrebandiers Cave and Dar Es-Soltan 2 (twelve and forty years, respectively, after their last excavations by Dibble, El Hajraoui, and Debénath) using the same methods of excavation and material analysis. By collating the published information from all these sites and some new insights from our current work, here we will integrate the archaeological contexts of the known human fossils from this area. We will discuss their depositional settings, known technological and faunal diversity, and environmental background behind accumulation of these deposits.

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# Archaeology of the Odele Member at Gona, Afar, Ethiopia

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The Odele Member of the Busidima Formation at Gona, Ethiopia, spans 160–7 ka and documents fluvial aggradation and degradation cycles coinciding with MIS 5, MIS 3, and the African Humid Period. To date, archaeological survey at Gona has found that the majority of Late Pleistocene and Holocene sites also coincide with these pluvial phases. The earlier sites have stone tool assemblages that typify the Middle Stone Age (MSA), with preferential and recurrent Levallois cores, blade cores, points, and tools such as denticulates, burins, and perforators. Later Stone Age (LSA) lithic types are found at the more recent sites, with smaller planimetric and volumetric cores, backed pieces, bladelets, and increased presence of personal adornments such as ostrich eggshell beads. The documentation of multiple open-air archaeological sites from several time intervals over the past 100 kyr at Gona, many with well-preserved fauna (e.g., YAS1, BSS3, and most ODS and KLT sites), presents an opportunity to understand better the cultural changes that took place in the Horn of Africa during the Late Pleistocene and early Holocene—especially when seen in combination with the nearby open-air sites at Aduma and Halibee, and cave sites in the region such as Porc Epic and Goda Buticha. Riparian corridors of the Awash River valley and tributaries during pluvials likely allowed people to move more freely between the Awash watershed and adjacent areas including the Red Sea, Blue Nile catchment, and/or Arabian Peninsula. Our continuing archaeological investigations will be important in documenting how humans responded and adapted to fluctuating climate states in the Horn of Africa and how they may have moved and interacted with neighboring groups during times that likely witnessed significant population expansions, contractions, and dispersals.

**Acknowledgements:** We would like to thank the Ethiopian Heritage Authority (EHA), Ministry of Tourism (formerly ARCCH), and the Afar Culture and Tourism Bureau (Semera, Ethiopia) for the relevant research permits. Major funding and long-term support have been generously supplied by the L.S.B. Leakey Foundation. The EU Marie Curie (FP7-PEOPLE-2011-CIG), MINECO (HAR2013-41351-P), and the Ministry of Science, Innovation & Universities, Madrid, Spain (PALEOAFRICA PGC2018-095489-B-I00) also provided significant funding. The Connecticut State University system has supported this research through the CSU Research Grant program.

## Ecomorphic Analysis of Bovid Astragali at the Fort Ternan, Kenya Miocene Site

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Fort Ternan, Kenya is home to one of the most extensively studied hominoid fossil sites from the Middle Miocene (c. 13.7 Ma) of Africa. Following the discovery at the site and initial description of *Kenyapithecus wickeri* by Louis Leakey in 1962, excavations over the next decade uncovered thousands of large mammal fossils and dozens of primate individuals representing at least six taxa. The primate remains themselves are extremely fragmentary, leading to standing questions about the behavioral ecology of these animals at a crucial point in hominoid evolution. However, another large mammal taxon, bovids, are much better represented, making up most of the collection and including thousands of postcrania in various states of preservation and articulation. While bovids arose in the Early Miocene, their presence at Fort Ternan predates the diversification in size and body type seen in their later Pleistocene and present-day analogues. We apply an ecomorphic analytical method developed by Barr (2014) for use with Pleistocene bovid astragali (talus) to the multi-taxon assemblage of contemporaneous and associated bovids from Fort Ternan, with the goal of inferring the likely preferred habitat type of the fossil individuals. Based on previously developed metrics associated with habitat preferences (Open, Light Cover, Heavy Cover, and Forest), we collected the same measurements on all complete fossil bovid astragali from the Ft. Ternan collection (n=32). A Linear Discriminant Analysis of this dataset (LD1 trace proportion=0.9139; LD2 trace=0.0738) shows a distribution of likely preferred habitat types that reinforces the conclusions of existing literature on Fort Ternan's paleoecology—namely, that the site consisted of a mosaic woodland with significant open areas. This serves as a simultaneous validation of the ecomorphic habitat-identification approach for pre-Pleistocene bovid astragali, as well as a successful replication of the results generated from 20th century paleoecological analyses of the site.

**Acknowledgements:** The authors would like to thank the National Museums of Kenya for graciously granting their affiliation request for the purposes of working on this project. In particular, we would like to thank Professor Mary Gikungu, Dr. Emmanuel Ndiema, and Samuel Muteti, as well as Jimmy Yatich and all of the employees and affiliated researchers at the National Museum for their generous and invaluable assistance. We also appreciate Alyssa McGrath and Dr. Alison Brooks for their support and feedback during the data collection process.

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## Revisiting the *Homo erectus* Site of Tighennif (Formerly Ternifine), Algeria. Results of New Multidisciplinary Investigations

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Tighennif (formerly Ternifine, Algeria) is a central site in North Africa to investigate *H. erectus* behavior and land use patterns and how they relate to dry/open environment. Chronologically, Tighennif correlates with the Early-Middle Pleistocene Transition (MPT) (1.2–0.7 Ma) during which Africa experienced a major global climate change characterized by increased aridity and open vegetation. This climatic change is associated with major events related to *H. erectus* biology and behavioral innovation, including the broad geographic expansion of this hominin species, increase in body size, and rapid expansion in cranial capacity, sophistication of the Acheulean technology, and control of fire. Tighennif yielded *H. erectus* fossils associated with a savanna-like fauna and an Acheulean industry. Because earlier research at this site was purely paleontological, several questions remain ambiguous, including accurate stratigraphic information, precise age of the sediments and associated materials, nature of the association between fossil bones and stone artifacts, and overall behavioral implications of the archaeological occurrences. To shed light on the above questions as well as to examine *H. erectus* behavioral patterns relative to ecology, multidisciplinary investigations are currently undertaken at Tighennif, including excavations, stratigraphic and taphonomic studies, and dating of the archaeological deposits. Field investigations and laboratory analyses reveal that: i) stratigraphic variation within the

site suggests the possible occurrence of more than one archaeological layer, ii) the site is older than the age reported previously; iii) taphonomic evidence shows that the material was minimally disturbed; iv) overall the archaeological material is in low density but the bones largely outnumber the lithic artifacts; and, v) evidence of cutmarked and hammerstone-percussed bones indicate that Acheulean hominins had primary access to large animal carcasses and also modified their bones into potential tools. Overall, our results suggest that *H. erectus* not only coped well with the dry environment but also was innovative technologically.

**Acknowledgements:** The authors would like to thank the Algerian Ministry of Culture and Arts for research permit to carry out investigations in Tighennif. Funding was provided by grants from CNRPAH (Algeria), The L.S.B. Leakey Foundation (California, USA), Fundación Palarq (Spain), MINCIU (PGC2018-095489-B-I00 & PID2022-137070NB-I00) (Spain).

## Analyzing Obstetric Adaptations in Incomplete Hominin Pelves: A New Method for Predicting Unpreserved Pubic Morphology

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The decrease in pelvic cavity dimensions that accompanied hominin pelvic adaptations for bipedal locomotion led to an obstetrical dilemma that required further pelvic adaptations to accommodate. The timing and morphology of these adaptations is largely unknown due to the hominin fossil record preserving few complete pelves from likely female individuals. Most hominin pelvic fossils preserve the more robust ilio-ischial region surrounding the acetabulum, making it difficult to measure, let alone interpret, fossil hominin birth canals. Here we present a new method for predicting this unpreserved anatomy so that obstetric-related anatomy can be compared in a greater number of fossil species. We combined Statistical Shape Modelling (SSM) with 3D geometric morphometrics to statistically predict the missing pubis and ischium from preserved ilium anatomy. We validated this method by applying it to four nearly complete hominin ossa coxae to see if our prediction method yields the anatomy preserved in the original fossils. Our fossil sample included A.L. 288-1 (*Australopithecus afarensis*), Sts 14 (*A. africanus*), Kebara 2 (Neandertal), and Ohalo 2 (early *Homo sapiens*). We built two prediction models, one based on 113 *H. sapiens* and a second based on the human sample combined with 79 *Pan* individuals. In our preliminary results, the human-only model predicted a relatively short and human-like pubic ramus that is very different from the original fossil morphology. The pooled model predicted an elongated pubic ramus that was more similar to the original fossil morphology and orientation. These results suggest that including non-human primates is essential for better predicting the anatomy of the ischiopubic region in fossil hominins. The SSM model described here has the potential to vastly increase the sample of fossil hominins for which birth canal morphology can be assessed.

## Dental Microwear Texture Analysis of Early Holocene People from the Fucino Basin, Abruzzo, Italy

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The cave sites of La Punta, Maritza, and Ortucchio, located in the Lake Fucino basin in Abruzzo, Italy, bear evidence for intermittent habitation by Early Holocene humans. The sites date from about 11,800 to 10,500 years ago and the habitation events occurred when the Fucino basin was a lake, and the environment was cold and dry. Subsistence evidence includes a high number of fish bones at Martiza and Ortucchio but few fish remains at La Punta. The current study seeks to determine if there is dental microwear texture evidence consistent with fish consumption at these sites. In general, eating fish yields little molar surface micro-relief compared to consumers of plant foods, particularly people who eat nuts and seeds. The dental microwear texture analysis (DMTA) employed herein followed standard procedures and included the variables complexity, anisotropy, and textural fill volume. The sample includes adult males from Maritza (Ind. 2) and La Punta, and two adults from Ortucchio (Ind. 1 & 2). The La Punta male had an elevated complexity (1.93), while Ortucchio 1 and 2 (1.37 and 1.10) and Maritza (1.28) had low values. La Punta, Maritza, and Ortucchio 2 had anisotropy values over 0.0030. Maritza had the highest textural fill volume. The microwear texture data indicate hard food consumption for La Punta, and a softer/tougher diet for Maritza and Ortucchio. All but Ortucchio 1 indicate having relatively homogeneous diets. The DMTA signatures, therefore, comport with the subsistence records; the people from the caves having evidence of fish exploitation, Maritza and Ortucchio, have microwear signatures expected for people consuming fish.

**Acknowledgements:** This research was funded by a grant from the National Science Foundation to CWS (BCS-0922930).

## The OGS-6/-7 Sites from Gona, Ethiopia, Revisited

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The OGS-6 and -7 sites in the Ounda Gona South area of Gona were discovered in 2000, and preliminary research results on different aspects of the stone assemblages have already been published. The lithic artifacts and associated fauna with cutmarks at these sites were securely dated to 2.6–2.55 Ma using $^{40}Ar/^{39}Ar$ and paleomagnetism, and are among the earliest well-dated *in situ* Oldowan occurrences. Previous publications elaborated upon aspects of the faunal exploitation, stone raw material selectivity, lithic technology, and probably cultural traditions represented by the OGS-6/-7 archaeological assemblages. However, all publications up to now have relied on data from the original 2000 excavations. Additional new excavations carried out at OGS-7 resulted in further discovery of abundant stone artifacts and associated fossil fauna. Here we report on some updated observations from this new assemblage, as well as supplemental collections from OGS-6. In some respects, the additional materials that we have recovered support previous inferences concerning, for example, raw material selectivity and carcass processing. The recovery of numerous small cores, though, in addition to several lithic refitting sets, allows us to describe in more detail the lithic technology exhibited by these assemblages. It is also important to examine the Gona materials in light of presumably older archaeological materials recently reported from several sites in East Africa. Comparisons will be made with the other early sites known at Gona, in particular the East Gona sites (EG-10, -12, -13. etc.).

**Acknowledgements:** We would like to thank the Ethiopian Heritage Authority (EHA), Ministry of Culture and Tourism (formerly ARCCH), and the Afar Culture and Tourism Bureau (Semera, Ethiopia) for the relevant research permits. We are also grateful to the Palaeoanthropology Laboratory, National Museum of Ethiopia for overall assistance. Major awards and grants were made by G. Getty and the L.S.B. Leakey Foundation. The EU Marie Curie (FP7-PEOPLE-2011-CIG), MINECO (HAR2013-41351-P) and the Ministry of Science, Innovation & Universities, Spain (MINCIU) (PGC2018-095489-B-I00) provided major support. Additional funding was provided by NSF (SBR-9910974 and RHOI BCS-0321893 to T. White and F.C. Howell), the Wenner-Gren Foundation, and the National Geographic Society (EC-52923R-18).

## Applications of TEX86 Paleotemperature Reconstruction Method at the Late Stone Age Sites of Txina Txina and Zimuara in Mozambique

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Advances in organic geochemical analysis have introduced two analytical techniques, one for marine, and the other, TetraEtherIndex of 86 carbons (TEX86), for non-marine aquatic settings. GDGTs are microbial membrane spanning lipids found in abundance in soils, peats, aquatic sediments, and elsewhere, and are divided into two dominant groupings for analysis: 1) bacterially synthesized branched GDGTs and 2) archaeal synthesized isoprenoid GDGTs. Since cyclization of both groups is dependent on the organism's environment, the distribution of GDGTs effectively records environmental conditions of the organism's life; as such, changes in the membrane composition can be used to reconstruct temperature and other environmental parameters. The synthesis of GDGTs from non-marine aquatic settings has generally been limited, on the African continent, to lacustrine settings. However, in altering the protocols, TEX86 has the potential to be applied to aquatic landscapes more broadly. In this study, two inter-hydrological basin sites, LSA site Txina Txina in the Limpopo Basin, and the MSA-LSA site Zimuara located in the Save Basin have been selected for analysis. Application of the TEX86 method for paleotemperature reconstruction at the Txina Txina site was, at first, unsuccessful. However, further analysis of the sediments from this site show that the initial failed attempts do not reflect in an inapplicability of this method in aquatically mediated burial settings, but rather, the inappropriate sediment collection and curation methods of the sampled material. With TEX86, sediment samples require cold and photophobic conditions for pristine recovery of GDGTs. This poster presents the preliminary temperature data from LSA contexts from Txina Txina and Zimuara and demonstrates the applicability of the method in archaeological settings, outlining the collection and curation methods required to successfully preserve GDGTs. We will additionally show how archaeologists can determine if this method of temperature reconstruction would be appropriate at their site.

## Habitat, Precipitation, and Seasonality Reconstructions Using Fossil Fauna from 2.8–2.6 Ma Localities in Ledi-Geraru, Afar Regional State, Ethiopia

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Previously we reported on habitat aridity in two time periods (2.78 Ma and 2.63 Ma) in the Lee Adoyta Basin of the Ledi-Geraru Research Project (LGRP), including sediments containing early *Homo*. Additional fossil collection in these areas and other parts of the LGRP call for an update to these reconstructions. Here we examine spatial differences in habitat for five different areas within the Gurumaha (2.78 Ma), two in the Lee Adoyta (2.63 Ma), and two in the Golden Sands (<2.63 Ma) regions. We also compare mammal fossils across these regions to explore both faunal and habitat variation through time. Functional traits (substrate use and diet) of mammalian species in each of the nine fossil areas were analyzed in a correspondence analysis (CA) with modern herbivore communities. Over-

all, fossil localities within the CA were encompassed by the distribution of modern sites. Precipitation and seasonality indices of the modern communities were also regressed against the CA Axis 1 scores to predict these variables for the fossil areas. Within the oldest period (2.78 Ma) we found the five different spatial areas for which we reconstructed habitats were different; this suggests either the landscape or the depositional environment varied among them, or that they were deposited at slightly different times. The two areas from 2.63 Ma were different from the older period and more arid. Finally, the two youngest areas (<2.63 Ma) had more similar habitats to one another despite being geographically the furthest apart. These were also predicted to have been wetter than the earlier sites. These results enable us to map a tentative landscape across space and through time for early *Homo*.

**Acknowledgements:** This research was funded by the National Science Foundation (NSF BCS-1853341 and BCS-1853362).

## Primate Teeth as Proxies for Understanding Water Inputs and Past Seasonality

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Scholars have long endeavored to document past environmental variation at a finer time scale than those available from sediment layers or ice cores. Teeth record dietary inputs throughout formation and do not remodel during life, yielding the environmental variation of ingested water via isotopic analysis. We employ Sensitive High Resolution Ion Microprobe (SHRIMP) measurements of enamel oxygen isotope compositions ($\delta^{18}O$), informed by daily growth increments, to facilitate sequential weekly sampling over years of enamel growth. Our previous studies have identified seasonal behaviors in Neanderthals (Smith et al. 2018), replicated historic African rainfall patterns (Green et al 2022), identified physiological changes at birth (Smith et al. 2022), and demonstrated meteorological events such as sustained droughts, extreme rainfall events, and possible supra-annual ENSO cycles (Green et al. 2022; Smith et al. 2023). Here we compare enamel $\delta^{18}O$ values, drinking water $\delta^{18}O$ values, local rainfall amounts, and medical and nursing histories from eight young captive rhesus macaques (*Macaca mulatta*) raised in Davis, California, between 2010 and 2022. Our result confirm that the innermost enamel often yields a faithful record of ingested water composition, with higher $\delta^{18}O$ values during warmer, drier times, and lower values during cooler and wetter seasons. Macaque enamel $\delta^{18}O$ values do not typically peak during exclusive suckling, nor is such isotopic enrichment evident in humans and orangutans (Smith et al. 2023), unlike expectations from other mammals. Enamel $\delta^{18}O$ values from primates using the same water source can vary by ~1–2 per mil. This may be due, in part, to metabolic distances during postweaning dehydration/diarrheal illness and subsequent medical interventions, which often correspond to brief isotopic deviations and accentuated growth increments. Isotopic variation may also be due to inadvertent sampling above the rapidly-mineralized innermost enamel zone, reported to be only 8 microns thick in macaques (Suga 1989). Overall, this study further validates our fine-scaled SHRIMP sampling approach, and the continued use of early-forming primate teeth, for high-fidelity paleoseasonality reconstruction.

**Acknowledgements:** Funded by the Australian Academy of Science Regional Collaborations Program and the Australian Research Council (DP210101913).

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## Paleoecological Implications of the Lateglacial Hyena Den from Besaansklip (Southwestern Cape, South Africa)

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South Africa's Cape Floristic Region (CFR) has been a hotspot for research regarding the relationships between modern human behavioral origins, Quaternary climate dynamics, and terrestrial ecosystem change. In contrast to the hyper-diverse fynbos vegetation that dominates the southwestern Cape today, previous research has suggested glacial periods of South Africa were dominated by grassy vegetation. However, the scarcity of reliably dated Pleistocene mammal assemblages, particularly on the CFR's west coast, has made it difficult to link faunal turnover to Pleistocene environmental change. Here, we present a paleoecological analysis of mammals from a well-dated Lateglacial (~16 ka) hyena den, Besaansklip, from the southwestern Cape. We conducted a triple oxygen isotope analysis ($\Delta'^{17}O$) on 10 ostrich eggshells (OES) from the site to estimate $pCO_2$ during the Lateglacial period in the region. The $\Delta'^{17}O$ of OES are

consistently higher than $\Delta'^{17}O$ from modern samples, aligning with the expectations of low $pCO_2$ during glacial periods. Besaansklip has high species abundance and richness of large grazing herbivores, many of which are extinct (e.g., *Equus capensis* and *Syncerus antiquus*) or extirpated (e.g., *Connochaetes gnou*). We apply previously developed ecometric methods to relate the faunal composition to water deficit. Our results indicate that Besaansklip has a much lower water deficit than today, likely because of increased rainfall or lower evapotranspiration due to cooler temperatures. These findings support previous models that propose a connection between low $pCO_2$, the expansion of grassy vegetation, and increased moisture availability during glacial periods of the Pleistocene.

**Acknowledgements:** Funding provided by NSF Coupled Natural-Human Systems grant (182666), NSF GRFP to KS (2023319052), the Global Change & Sustainability Center, and the Wilkes Center for Climate Science & Policy.

## Forward Modeling of Walking in Humans with Different Hip Widths

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In their assessment of the pelvis of *Australopithecus afarensis*, Lovejoy et al. (1973) suggested that wider hips are less efficient than narrow ones given the lever-arm mechanics of the one-leg stance. This view provided a rich ground for polemics around the role that hip width may have had in the evolution of human sexual dimorphism and mechanical trade-offs in the human pelvis. Recently, Kramer and Sylvester, (2023) showed that the cost of transport incurred by the abductor muscles can be fully accounted for by the variation in the body mass and the velocity of motion, while variation in the distance between hip joints has no effect. To explore the effect of wider hips on motion, we simulated human walking with the help of forward kinematics (Falisse et al. 2019) in a fully controlled digital environment. Using the model by Hamner et al. (2010) we predicted walking motion for three cases: (a) the baseline model, (b) the baseline model with the mass increased by 50%, and (c) the baseline model whose pelvis width was increased by 50%. We demonstrate that the increase in pelvis width results in a higher cost of transport for the abductor muscles, which is comparable with the effect of mass. However, the total cost of transport does not change due to compensation in the knee and ankle joints. Implications and limitations of our study are discussed.

**Acknowledgements:** This work was possible thanks to funding from the Austrian Scientific Fund (FWF project P 25714-B).

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## Sexual Dimorphism of the Sacral Auricular Surface: A Preliminary 3D Geometric Morphometrics Analysis

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The human pelvis displays clear sexual dimorphism thought to be a result of the conflicting demands of walking upright and giving birth. Scholars believe that this sexual dimorphism is similarly manifested in the sacrum due to its substantial role in shaping the pelvic girdle. However, sexual classification accuracies remain inconsistent depending on the method and reference sample. With the functional morphology of the sacrum in mind, this project aims to address this inconsistency by quantifying sexual dimorphism in a geographically heterogeneous human sample (n=50, 25 males and 25 females), utilizing 3D geometric morphometrics to examine sexual dimorphism in the auricular surface of the sacrum. While previous studies investigate the auricular surface using 3D geometric morphometrics, none have exclusively analyzed the auricular surface using sliding semilandmarks on curves. Our geometric morphometric analysis was based on 8 landmarks and 20 sliding semilandmarks on curves collected from the left and right auricular surfaces of each sacrum. The results of this preliminary study show that, when analyzed using linear discriminant analysis, the sacral auricular surface is sexually dimorphic. This may provide insight into the evolutionary forces acting on sacral morphology while simultaneously providing a novel method of sex determination for fragmentary remains.

**Acknowledgements:** We thank the following individuals and institutions for allowing us access to human skeletal material and fossils in their care: G. Garcia and A. Hammond (American Museum of Natural History), L. Jellema and Y. Haile-Selassie (Cleveland Museum of Natural History), B. Billings and A. Meyer (Dart Collection, University of the Witwatersrand), R. Ives (Natural History Museum), V. Laborde, L. Huet, D. Grimaud-Hervé, and M. Friess (Musée de l'Homme).

# A Comparative Study of Different Core Reduction Indices Using 3D Scanned Experimental Lithic Assemblages

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Stone tools make up a large portion of the record of human history. This rich record allows us to reconstruct the evolution of human behavior through time. In the Early Stone Age, the technological diversity of cores reflects the technical decisions of early toolmakers allowing us to investigate developments in hominin culture, cognition, and food acquisition. In order to link changes in core technology and morphology to evolutionary processes, researchers employ a wide range of quantitative and qualitative analytical techniques and methods. However, these methods are not consistently applied across field sites. Moreover, very little work has been done to examine the comparability and reproducibility of analytical methods used to study technological diversity among cores. In order to better understand the behavioral patterns embedded into lithic assemblages, investigations into how these different analyses correspond to each other are needed. This exploratory study examines the efficacy and comparability of different analytical techniques designed to describe core morphology and reduction intensity using experimentally produced cores. Our results explore the interrelationships between the different measures of diversity provided by these methods of core analysis, allowing us to better link our analyses with broader aspects of hominin behavior and evolution.

**Acknowledgements:** John Whittaker, Koobi Fora Field School, Grinnell College Anthropology Department.

# Utilizing Clinical Dentistry Technology to Assess Primate Dental Wear Progression

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Intraoral scanners, primarily designed for clinical dental applications, offer promising potential beyond their conventional use. This study explores their adaptability for evaluating dental tissue loss in non-human primates, specifically focusing on captive hamadryas baboons (*Papio hamadryas*). Over two- or three-year intervals, molds of upper and lower second molars were obtained from each baboon, totaling 24 teeth across the sample. Employing an intraoral scanner (Medit i700) and WearCompare software, we analyzed the scans to quantify tissue loss and assess wear progression. Our findings demonstrate the robustness of these techniques, showcasing consistent alignment between scans, minimal occurrence of false positive values, and uniform tissue loss patterns across individuals. Notably, the average tissue loss was 5.06mm$^3$ for the two-year observation group and 10.39mm$^3$ for the three-year group, translating to an average annual tissue loss of 3mm$^3$ (range: 2.53mm$^3$ to 3.46mm$^3$), with no significant disparity observed between maxillary and mandibular molars. Furthermore, the examination of molars afflicted by caries revealed notably heightened tissue loss levels (17.58mm$^3$ and 13.33mm$^3$ for affected teeth over three years), offering insights into pathological conditions affecting dental tissue loss. Beyond these immediate findings, this study suggests opportunities for paleoanthropological research. For example, these methods may allow the creation of new wear scoring techniques for fossil primates by better mirroring the rate of dental tissue loss over time, using extant primates as reference points. Additionally, these techniques will allow assessment of the interaction between dental tissue loss and microwear patterns through time, potentially illuminating further information from microwear patterns in extinct groups. These methods also promise insights into the genetic foundations underlying tissue loss variations within and among primate groups. Using clinical dentistry technology in this broader context opens doors to multifaceted inquiries into primate dental morphology, tooth wear, and oral health.

**Acknowledgements:** European Union's Horizon Europe (ERC-2021-ADG, Tied2Teeth, project number 101054659).

# The Academic Life and Legacy of Sally McBrearty (1949–2023)

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An understanding of the current state of paleoanthropology is incomplete without an appreciation for the history of intellectual thought that informs it. We take this opportunity to situate the career of Professor Sally McBrearty within the history of the discipline, and to share our steps to preserve her academic legacy. Sally will likely be best remembered for her work, with co-author Alison Brooks, on *The revolution that wasn't: A new interpretation of the origin of modern human behavior* (McBrearty and Brooks 2000). This paper profoundly changed the narrative in 'modern human origins' debates to provide a more central role for Africans both past and present by better linking archaeological, biological, and chronological data for the origin of *Homo sapiens*. In addition to considering the development and lasting impact of this contribution, we emphasize how it was informed by five decades of archaeological fieldwork in eastern Africa (particularly near Lake Victoria and in the Kapthurin Formation of Kenya), her experimental and laboratory-based studies in site

formation processes, her deep attention to research history, and her emphasis on the evolutionary context of the archaeological record, the latter critical during her discovery of what remain some of the only known chimpanzee fossils. We emphasize her development of an academic program in Old World Archaeology at the University of Connecticut where she trained several cohorts of students and outline our continuing efforts to preserve her substantial documentary archive for use by future researchers.

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## The (Semi) Arid Ape: How the Rift Valley Defined Our Niche

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Hypotheses about drivers of human evolution often address how hominins are ecologically distinct from closely related apes. These hypotheses have common ingredients, and many suggest that the topography and vegetation of the Eastern African Rift Valley System (EARS) contributed unique selective pressures in hominin speciation events. We suggest a new semi-arid ape hypothesis that centers on the environment as a force in early hominin evolution and combines ideas from previous hypotheses and recent research. Early hominins (7–3 Ma) likely had species ranges that extend from mesic forests (found today on the rift highlands and extend into central and western Africa) to semi-arid regions, such as the lower parts (floor) of the EARS. This range of habitats is their fundamental niche. Semi-arid regions include the low elevation regions along the rift floor that are generally more arid than the regions surrounding them, in part due to higher temperatures, higher evaporation, and wind cycles. The semi-arid ape hypothesis proposes that drier components of the hominin range (the realized niche) separated hominins from non-hominin apes in the Mio-Pliocene. Chimpanzees today do not exploit the same type of semi-arid habitats as reconstructed for Pliocene hominins, nor are their fossils usually found in the same regions. We suggest that an early exploitation of semi-arid habitats, outside of the central-western African rainforest belt, resulted in a biogeographic separation between hominins and other apes. Adaptations to a broad range of environments and climates are fundamental for the human ability to survive in extreme environments today and may help us survive in more extreme future environments.

**Acknowledgements:** The University of Arkansas Research and Development and Pandemic Relief Funds and the Leakey Foundation.

## A Comparative Study of Reduction Sequences Methods: Application to Oldowan Technology

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The manufacture of stone tools is an evolutionary step in human evolution. The reductive nature of these assemblages allows archaeologists to explore the sequences of decisions made when making these tools. This can be identified through the sequence of removals in stone artifacts. This is often only possible with cores that can be refitted. In the absence of refits, inferences on reduction sequences can sometimes be made through flake attributes. Here we track existing methodologies of interpreting Oldowan lithic reduction sequences using experimental assemblages as guides. We collected attributes on experimentally produced artifacts (whole flakes from raw materials available in the Koobi Fora Formation) that are related to the reduction of Oldowan cores. We examined multiple methods for identifying sequence information in whole flakes. Here we explore various independent methods of identifying flake sequence and their application to archaeological assemblages. We applied a multi-linear regression model that integrates diverse variables. This regression predicts sequence values that are highly correlated with known sequence values. However, this method frequently over- or underestimates the known sequence value in experimental data sets. Machine learning models predict sequence number relatively accurately (even across cobbles of varying sizes). Yet even these models predict exact sequence number <20% of the time. Linear discriminant functions can accurately distinguish between groups of sequence values (e.g., flake removals 1–5) at much higher accuracies (>45%). Predicting exact sequence number from flake attributes remains elusive. When these models are applied to various archaeological assemblages, the different estimates of sequence will over- or underemphasize certain parts of the flaking sequence. This has implications for how we understand patterns of behavior in the past. We explore how specific variables influence the different models and how this develops stronger inferences about the movement of stone on ancient landscapes.

**Acknowledgements:** This research was supported by awards from the National Science Foundation (SBE-REU 1852441, Archeology Program 1624398); the Leakey Foundation and the PAST Foundation.

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# The Missing Oldowan: The Early Stone Age from 2.3 to 2.0 Ma at the Nasura Site Complex, West Turkana, Kenya

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The period between 2.3 and 2.0 million-years-ago (Ma) has been characterized as one of the critical points of transition in the hominin lineage. One that saw the widespread dispersal of stone technologies from sporadic, spatially restricted occurrences prior to 2.3 Ma, and the expansion of numerous derived hominin forms by 2.0 Ma. Despite its importance, our understanding of this period is inhibited by the relative dearth of well-dated archaeological and paleoanthropological occurrences. The Nasura (NAS) site complex from the Nachukui Formation of West Turkana, dated between 2.3 and 2.0 Ma, offers a unique opportunity to investigate this critical interval and explore diachronic changes in hominin behavior, cognition, and foraging patterns. NAS is particularly well-suited for such a study due to its four *in situ* archaeological occurrences found close together in both space and time and associated with hominin fossils, as well as high-resolution paleoenvironmental records. Here we present preliminary results from NAS1, 2, 3, and 4. Through comparisons between the sites at NAS, we hope to clarify long held debates and address questions of technological change and behavioral evolution in the Early Stone Age.

**Acknowledgements:** We'd like to thank the National Museums of Kenya, the Kenyan National Commission For Science, Technology & Innovation, the Turkana Basin Institute, the Centre National de la Recherche Scientifique, the Institut Français de Recherche en Afrique, the Institut National de Recherches Archéologiques Préventives, and the Turkana people in the Nasura and Kokiselei areas.

# Differences in the Rotational Profile of the Lower Limb Among Humans and Non-Human Primates

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The rotational profile of the lower limb includes femoral torsion (FT), tibial torsion (TT), and talar neck angle (TNA). In humans, these angles affect the mobility of the hips, rotation of the knees, and angle of the foot during walking and standing. Yet, while there is a broad understanding of how these variables affect locomotor variability in humans, it is not clear how they might be related to various locomotor modes across the order Primates. Here, we examine how the rotational profile of the lower limb varies between humans (n=30) and non-human primates that primarily utilize different locomotor modes, namely terrestrial quadrupedalism (n=14), arboreal quadrupedalism (n=33), suspension (n=30), and knuckle-walking (n=20). Lower FT was expected in suspensory primates due to high degrees of external rotation possible at the hip. Lower TT was expected in all primates relative to bipeds related to the higher degree of foot inversion in taxa with an abducted hallux. Finally, lower TNA was expected in bipeds related to the adducted hallux. All variables in the rotational profile were derived from whole-bone 3D models. Differences between groups were assessed using ANOVA and *post hoc* Tukey's pairwise tests. Relationships between FT, TT, and TNA were evaluated with correlations. There were significant differences in FT, TT, and TNA between the locomotor groups. Bipeds had significantly higher FT than suspensory primates, arboreal quadrupeds, and knuckle-walkers. Bipeds had significantly higher TT and significantly lower TNA than all other primates. Overall, this suggests that bipedality has resulted in a unique signature in the rotational profile of the lower limb. In the femur this might be related to reduced external rotation at the hip. For both the tibia and the talus, this is perhaps related to the adducted hallux and longitudinal arch in the foot resulting in reduced inversion.

**Acknowledgements:** We would like to thank Karin Wiltschke-Schrotta and August Walch (Vienna Natural History Museum), Holly Wardlow and Kathy David (University of Toronto), Mark Omura and Madeleine Mullon (Harvard Museum of Comparative Zoology), Eleanor Hoeger, Marisa Surovy, and Sara Ketelsen (American Museum of Natural History), and Megan Viera and Darrin Lunde (National Museum of Natural History) for facilitating access to collections. We'd also like to thank the Hal Jackman Foundation, the Department of Anthropology and School of Graduate Studies at the University of Toronto, and the Social Sciences and Humanities Research Council of Canada for funding for this project.

# Identification and Quantification of Projectile Impact Marks on Bone: New Experimental Insights Using Osseous Points

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Shifts in projectile technology potentially document human evolutionary milestones, such as adaptations for different environments

and settlement dynamics. A relatively direct proxy for projectile technology is projectile impact marks (PIM) on archaeological bones. Increasing awareness and publication of experimental data sets have recently led to more identifications of PIM in various contexts, but diagnosing PIM from other types of bone-surface modifications, quantifying them, and inferring point size and material from the bone lesions need more substantiation. Here, we focus on PIM created by osseous projectiles, asking whether these could be effectively identified and separated from lithic-tipped weapons. We further discuss the basic question raised by recent PIM research in zooarchaeology—why PIM evidence is so rare in archaeofaunal assemblages (compared to other human-induced marks), even when they are explicitly sought. We present the experimental results of shooting two ungulate carcasses with bone and antler points, replicating those used in the early Upper Paleolithic of Western Eurasia. Half of our hits resulted in PIM, confirming that this modification may have been originally abundant. However, we found that the probability of a skeletal element to be modified with PIM negatively correlates with its preservation potential. Moreover, much of the produced bone damage would not be identifiable in a Paleolithic faunal assemblage that often undergoes fragmentation under typical preservation conditions. This quantification problem still leaves room for an insightful qualitative study of PIM. We complement previous research in presenting several diagnostic marks that retain preservation potential and may be used to suggest osseous, rather than lithic, projectile technology. The results will serve to improve the association between osseous projectile tips and game remains, especially in the Upper Paleolithic of Europe and the Levant.

**Acknowledgements:** This research was funded by the Leakey Foundation research grant (to K.K.) and benefited from the scientific framework of the University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past" (LD). J.-M.T. is supported by a project of the Meitner Program of the Austrian Science Fund (FWF) (Project: Osseous Hunting Weapons of Early Modern Humans in Eurasia. Number M3112).