Evidence for Bipedal Locomotor Diversity in the Plio-Pleistocene from External Femoral Diaphyseal Morphology

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The investigation and interpretation of locomotion from hominin long bones has aroused considerable controversy, especially in the study of Early Pleistocene hominin remains. The difficulty of identifying taxa and quantitatively assessing morphological differences based on the findings of isolated and usually incomplete long bones increases as more species are being discovered and the evolutionary picture becomes more complex. Here we present a novel approach based on the use of a dense semilandmark net and geometric morphometric techniques to study femoral morphological diversity in fossil hominins while overcoming some of the problems imposed by the lack of epiphyseal remains. For the purpose of this study, we have selected the best-preserved homologous region in several hominin femora, namely the region directly below the lesser trochanter, from australopiths (*Australopithecus afarensis*, *Paranthropus boisei*), early *Homo* (*Homo habilis*, *Homo rudolfensis*, *Homo erectus*) and Mid-Pleistocene *Homo* specimens (*Homo naledi*, *Homo neanderthalensis*). The generation of a dense semilandmark net and its projection onto the femoral shaft provides anatomical information with regard to external morphology that cannot be captured by fixed anatomical landmarks. The combination of the detailed descriptive tool provided by the semilandmarks and the calculation of biomechanical dimensions of shaft cross-sectional shape at the subtrochanteric region of the femur from the semilandmarks provides insights into the diversity of morphology and the biomechanical significance of these variations in the fossil record. Results are in line with hypotheses suggesting that orthograde postures would have been part of the ancestral locomotor repertoire, which may have promoted the posterior emergence of terrestrial bipedality. Whatever the origins of bipedality, our analyses also provide evidence of bipedal locomotor diversity among Plio-Pleistocene hominins.

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Further Morphological Assessment of a Partial Hominin Pelvis (DNH 43) From the Site of Drimolen, South Africa

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The paleocave site of Drimolen in Gauteng Province, South Africa, has produced fossil hominin material dating to between 2.04–1.95 Ma. The assemblage includes craniodental remains attributed to *Paranthropus robustus* and the earliest specimen of *Homo* aff. *Erectus*, along with numerous postcrania of uncertain taxonomic affiliation. Notably, *Paranthropus* and *Homo* were effectively contemporaneous at the site and coeval with *Australopithecus* from nearby fossil localities in South Africa. Among the Drimolen postcranial fossils is a partial pelvis (DNH 43), which includes elements of the right os coxae and an associated sacrum. Though previously described as showing similarities to the pelvis of *Australopithecus africanus* and *A. afarensis*, comparisons across the broader hominin fossil record have been limited and the specimen has never been subject to quantitative analysis to assist in determining its closest morphological affinities. Here we present a partial digital reconstruction of DNH 43 and compare it to an expanded dataset of hominin pelvic material using a suite of metrics taken on 3D scans. In absolute measurements, DNH 43 is most similar to specimens attributed to *Paranthropus* and *Australopithecus*. However, in size-adjusted metrics the os coxae exhibits its closest affinities with specimens SK 3155b (*P. robustus* from Swartkrans) and OH 28 (typically attributed to early *Homo* from Olduvai Gorge). The sacrum is relatively narrow in the anteroposterior dimension, linking it with early hominins including *A. afarensis* and *A. africanus* versus modern *Homo sapiens*. However, there are no sacral specimens attributed to *Paranthropus* against which DNH 43 can be compared. Overall, the quantitative analysis confirms prior qualitative results reflecting the primitive features of DNH 43, but highlights the need for a better understanding of *Paranthropus* postcranial anatomy, especially vis-à-vis the species of early *Homo* with which it overlapped chronologically in both southern and eastern Africa.

Trace Element Concentrations as Screening Tools for Detecting Diagenesis in Archaeological Hard Tissue

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Isotope ratio analyses of elements such as strontium and lead are commonly used with tooth enamel, ostrich eggshell, and other archaeological hard tissues to infer mobility and other aspects of hominin and faunal paleoecology. It is assumed that these highly mineralized tissues are resistant to diagenetic alteration but this is seldom tested and some studies have documented profound alterations over very small time spans. To develop screening tools for diagenesis that can inform heavy isotopic analyses, we expand previous work on Maximum Threshold Concentrations (MTCs). The premise of the MTC approach is that modern, unaltered hard tissues will exhibit characteristic concentration ranges of trace elements. When these concentrations are exceeded in archaeological tissues, the specimens are likely contaminated and unsuitable for isotope ratio analysis. Furthermore, we propose a new metric called the Maximum Threshold Ratio (MTR) of 85Rb/88Sr, which can be applied during *post hoc* screening of specimens or measured simultaneously with 87Sr/86Sr during laser ablation MC-ICP-MS. We analyzed 56 enamel samples from modern Kenyan mammals and 34 modern ostrich eggshells from South Africa, Namibia, and the United States by solution ICP-MS, as well as subset of eggshells using LA-ICP-MS and LA-MC-ICP-MS. Enamel results show that MTCs and MTRs are highly consistent across taxa at a single location, suggesting that common thresholds can be applied to different taxa. Ostrich eggshells produced substantially different thresholds based on locality of provenience, suggesting that reference concentrations might need to be locality-specific. Other important differences are observed between the inner and outer surfaces of the eggshells (the latter having higher concentrations of trace elements) and between laser ablation and solution ICP-MS. This exploratory study provides guidelines for building project-specific reference thresholds to screen enamel and eggshell for diagenesis potentially impacting biogenic isotope ratios.

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Shape and Size Variability in Upper Paleolithic Magdalenian Rondelles: Dimensions of Interaction and Implications for Different Production Sequences

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Rondelles, artistic objects from the Magdalenian of Western Europe, are commonly categorized due to their circular appearance, central perforation, and frequent presence of engravings. Multiple hypotheses exist regarding the function of these objects, but studies have not yet addressed if there are shared ranges of dimensional attributes (i.e., material, size, weight, shape, perforation characteristics), nor if there are shared technological sequences of production of objects that are currently identified as rondelles. Testing for comparable suites of traits and methods of manufacture outside of analyses of artistic decoration provides an additional lens to identify regional trends of production and shared cultural transmission. Our current research presents a standardized study of 175 complete and fragmented artifacts currently identified as rondelles from the French sites of Mas d'Azil, Bedeilhac, St. Michel (Arudy), and Isturitz. Measurements of rondelle weights, lengths, widths, and thickness were recorded in regards to overall shape as well as perforation qualities. For this study, we also noted anthropogenic tool traces from manufacture, as well as morphological and material artifact properties. Our results indicate a high degree of dimensional variability, highlighting that objects categorized as rondelles have varying qualities that challenge assumptions of the functional homogeneity of these objects and provide evidence for different aspects of production sequences, specifically raw material procurement. Trends of manufacture are also noted for methods of extraction (i.e., outlining) and perforation. This study complements prior research regarding ranges of characteristics of stylistic trends in Magdalenian mobiliary art (Fritz 1999), and can inform future hypotheses regarding rondelle function and life histories.

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Tephrostratigraphy and Archaeology in the Nyanza Rift, Kenya

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Modern human behavioral evolution in Late Pleistocene (126–12 ka) Africa is complex with Middle Stone Age (MSA) technologies disappearing and Later Stone Age (LSA) technologies appearing at different times in different places across the continent. Explaining this pattern requires refined chronological and stratigraphic control of the paleoanthropological record. This study employs tephrostratigraphy, the chemical correlation of volcanic ashes (tephras), to improve the chronostratigraphic context of modern human evolution. We expand the Late Pleistocene tephrostratigraphy to incorporate 13 terrestrial artifact and fossil bearing localities throughout the Nyanza Rift as well as correlation to the V95-1P lake core in the Ugandan waters of Lake Victoria. Compositional comparisons with proximal volcanic rocks link these Nyanza Rift tephras to their source provenances in the Central Kenyan Rift connecting sediments over an area >16,000km$^{2.}$ This geographically expanded tephrostratigraphy extends the known chronology of the Lake Victoria Basin to encompass later Middle Pleistocene (~240 ka) deposits as well as terminal Pleistocene and Holocene sediments. Correlations to the exposures of Songhor (GqJe-1) provide a later Middle Pleistocene (~180–150 ka) age for MSA materials. Correlations at the newly excavated MSA site of Anderea's Farm 1 (GrJe-8) to a tephra layer (VA3) overlying LSA layers at the site of Enkapune ya Muto (GtJi-12) in the Naivasha Basin further show interstratification of MSA and LSA technologies between 45–36 ka. A 50–36 ka tuff correlated to Muguruk (GqJc-1) suggests the possibility of a Late Pleistocene age for MSA and Sangoan/Lupemban materials at this site. By correlating tephras between sites as well as with their eastern Rift source provenances, the Nyanza Rift tephrostratigraphy provides the chronostratigraphic framework on which to base future paleoanthropological work on modern human evolution throughout the Lake Victoria basin and across a broader area of East Africa.

A Reflection on Use-Wear Analysis of Abraded Ochre

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Coloring materials, or 'ochre', include iron-oxide or clay-rich rocks that are relevant to prehistoric studies because of their association with art and ubiquitous presence in ethnographic records from around the world[1–6.] These materials provide a means to decorate or work surfaces and are considered proxies for broader social behaviors. Due to the recognized need for standardization and systematization in the discipline of coloring material studies, we created a use-wear reference collection for abrading techniques on various coloring material types. After observations, with the data collected from our experimental work, we were able to establish a technical vocabulary for specific ochre studies and create an analytical grid to help standardize future studies of coloring material assemblages. Qualitative data, in the form of striation measurements, allowed us to document a relationship between striation width on the abraded coloring material's surface and the size of the grains in the abrading material, for example grinding stones, allowing us to correlate the size of the grinding stones' granulometry with the coloring materials' striations. These findings also allowed us to prove that the type of coloring material has more influence on the size of the striations than the type of movement or addition of adjuvants during abrasion. Harder materials will have smaller and less variably sized striations, while softer materials will have larger and more variably sized striations. Still, more work needs to be done in order to fully understand the tribological properties and behaviors of each distinct coloring material.

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Why Did Projectile-Point Size Increase in the Andean Altiplano Archaic? An Experimental Atlatl Analysis

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Archaic projectile points from the Andean Altiplano exhibit a curious trend of increasing size over time, in contrast to a well-documented size reduction throughout North America. Although a number of hypotheses exist to account for decreasing projectile-point size, there are currently no explicit explanations for increasing size. We consider several hypotheses and interrogate two techno-economic hypotheses. We posit that increasing point size compensated for lost dart momentum or accuracy that resulted from the shortening of atlatls or atlatl darts as wood became increasingly scarce on the tree-sparse Altiplano. We evaluate these hypotheses using a

replicated Andean atlatl system in ballistic trials. Contrary to expectation, results show that point enlargement significantly reduces penetration depth, allowing us to confidently reject the momentum hypothesis. Point enlargement, in contrast, tentatively correlates positively with accuracy. Our experiment further shows that camelid bone is an effective and economical alternative to wood for atlatl production. Despite suboptimal lengths, camelid radioulna atlatls have a convenient morphology that requires low production time, which helps explain empirically observed camelid bone atlatls from the Andean highlands. More generally, our observations lead us to consider that central tendencies in archaeologically observed projectile-point size may reflect a trade-off between penetration and accuracy. Our future work will continue to investigate the relationship between point size and accuracy through more rigorous controlled and naturalistic experiments.

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Middle and Later Stone Age Faunal Remains from the Renewed Excavations at Border Cave (KwaZulu-Natal, South Africa): Preliminary Results

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With an occupational sequence spanning from >200,000–24,000 years ago, Border Cave has been the focus of more than 80 years of Stone Age research. Renewed excavations commenced in 2015; one of the primary aims of the current project is to develop greater contextual and chronological resolution for the site and its rich, well-preserved archaeological record. The sequence is characterized by a series of alternating Brown Sand (BS) and White Ash (WA) members; each of the defined archaeological industries is associated with at least one BS and one WA deposit. Given this, it is critical to evaluate the degree to which the BS and WA members have distinctive formation processes/taphonomic histories. The fauna provides a key source of information on the nature and extent of variation across the deposits. While our focus is on inter-member variation, we also explore faunal variation within a single member—2WA. Our sample includes all piece-plotted fauna excavated between 2015–2018 (n=1270) as well as material recovered from the screens during the 2017 season (n=8486). The total number of identified specimens (NISP) is only 335, necessitating a focus on taphonomic rather than taxonomic analyses. Our data suggest that caution is warranted when combining material from the BS and WA members in order to explore changes across archaeological industries, as variation in the taphonomic history of these assemblages likely impacts taxonomic data and results in differential preservation of skeletal elements in a way that complicates analyses of human behavior. It may be better to treat the members independently, in which case, larger samples will be necessary before addressing broader questions relating to human subsistence and landscape use. However, as evidenced in the consideration of variation within 2WA, treating members as homogeneous samples may also mask important variability, further highlighting the importance of high-resolution data collection/analysis.

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Osteogenic Potential of Activity Patterns and Robusticity of the Hominin Skeleton

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A guiding principle of behavioral inference in the fossil record is that there is nonspurious correlation between daily activity patterns (including traveling, foraging, and feeding) and the morphology of skeletal elements. One general expectation is that observation of increased robusticity reflects increases in frequency or intensity of past activity. Examples include the idea that Neanderthal postcranial robusticity is explained by inefficient bouts of prolonged foraging, or that facial hypertrophy (e.g., in Neanderthals or *Paranthropus*) indicates increased levels of masticatory and paramasticatory activity. The experimental literature in bone biology contains multiple examples of functional linkages between activity levels and skeletal mass and robusticity. More recently, however, it has been established that osteogenic signals from skeletal loading are transient during ordinary activity, such that uninterrupted activity has a limited effect on subsequent skeletal modeling. Turner and Robling (2003) argued that the effects of activity pattern on skeletal modeling is a simple function of the number of daily loading cycles and frequency and spacing of periods of rest. Using these mathematical func-

tions, I simulate daily loading profiles and their effects on subsequent modeling by creating randomized daily physiological strain rate spectra and periods of inactivity. Resting bouts are superimposed on the strain rate profile in intervals of 1 to 15 periods per day. The daily strain stimulus is punctuated by variable bouts of inactivity and relative osteogenic potential is calculated based on the refractory periods of the different rest intervals. Since timing of daily activity is decisive for creating an effective coupling of mechanical stimuli with subsequent bone formation, these simulations underscore the difficulty of explaining skeletal robusticity in the absence of specific activity data. Behavioral reconstructions must consider alternative granular activity scenarios for interpretation of skeletal changes associated with paleoecological shifts.

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A Comprehensive Analysis of Use-Wear Traces and Organic Residues on Middle Paleolithic Artifacts from Saradj-Chuko Grotto, Northern Caucasus, Russia

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Saradj-Chuko grotto is a Middle Paleolithic (MP) cave site located in the North-Central Caucasus, about 70km north-east of Mount Elbrus, and about 20km north-west of the city of Nalchik (the capital of the Kabardino-Balkaria Republic, Russia). The grotto sits in a deep (up to 200m) and forested valley of the Saradj-Chuko (or Fanduko) river (a small tributary of the Kishpek River, Baksan River basin), 26m above the river. Opening to the southeast, it has a area over 300m^2. The site was discovered in 2016 and excavated in 2017–2019 and 2021 (Doronicheva et al. 2017; 2019; 2020). The laminar technology differentiates the MP laminar Mousterian industry of the North-Central Caucasus, represented at present in Saradj-Chuko grotto and Weasel cave, from the Micoquian industry that is widespread in the North-Western Caucasus. At Saradj-Chuko grotto, three MP layers are defined (layers 6B, 6A and 3 from the bottom to top). We report new data on use-wear analysis and function of lithic artifacts from MP layers 6B, 6A and 3 and organic residues discovered on some tools at Saradj-Chuko grotto. Traceological studies were performed using the Semenov (1957) method, with methodological additions by Poplevko (2007) that include the study of the relationship between typological, technological, and traceological definitions of lithic artifacts. The study was carried out using a MC-2CR-ZOOM microscope with magnification up to 160x and a Sony-ZOOM camera for microphotography with magnification up to 240x. Scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (ED-XRS) were used for investigating microstructure, and the qualitative and quantitative composition of analyzed samples.

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Evaluating a Commonly Used Method for Placing Confidence Intervals on the Ends of Hominin Temporal Ranges

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Knowing when hominin taxa originated and went extinct is important for understanding the timing of hominin macroevolution and the potential drivers involved. Due to preservation and sampling biases, however, a taxon's observed temporal range is almost certainly smaller than its true range. It is therefore imperative that paleoanthropologists quantify the uncertainty surrounding estimated origination and extinction dates by calculating confidence intervals (CIs). One commonly used method combines the observed sampling probability of a hominin taxon (i.e., its relative abundance) with the number of mammalian specimens found in a stratum to calculate the probability of sampling at least one specimen from the hominin in question. To estimate a CI on the (for example) origination date, the number of specimens from strata increasingly older than the hominin's first appearance are added until a sufficiently high probability is achieved (e.g., 0.95). This method, however, has not been thoroughly explained from a statistical perspective, with the result that its assumptions are not clearly stated. Here, we derive the model from first principles using probability theory and demonstrate that the model follows a geometric distribution. Investigating one of the model's assumptions, we argue that a taxon's observed sampling probability is a parameter estimate with an associated margin of error. The geometric model ignores this error, causing calculated CIs to be erroneously too small (i.e., Type I error rate is too high). We show how the sampling probability parameter can be modeled using

a beta distribution, resulting in a CI model that follows the beta-geometric distribution. The beta-geometric results converge on those of the geometric as further sampling increases the precision of the sampling probability estimate. By elucidating what the geometric CI method is doing and its associated assumptions, future research can more accurately and judiciously estimate CIs for the ends of hominin temporal ranges.

Neotaphonomy of a Landscape Bone Assemblage in the Ngorongoro Conservation Area, Tanzania

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Identifying the variables that influence the deposition, preservation, and spatial distribution of faunal material across landscapes remains a key goal of taphonomic research. Here, we report on the results of pedestrian surveys for faunal material in two microhabitats within the Ngorongoro Conservation Area (NCA)—a treeless grassland and a seasonal waterhole surrounded by woodland. In both areas, all visible faunal material on the surface of a 100x100m block was plotted with a laser total station and collected. The overall density of bones is higher around the waterhole, but neither area shows distributions consistent with complete spatial randomness. High density bone patches near the waterhole are: (1) strongly conditioned by elevation and the distribution of trees, (2) often contain the remains of multiple individuals, and (3) preserve taphonomic traces of human and carnivore activity. On the other hand, bone patches on the treeless plain: (1) occur incidentally, (2) include the remains of only a single individual, and (3) lack evidence for human or carnivore intervention. These microhabitats, then, while separated by only ca. one kilometer, preserve distinct taphonomic signatures. These findings can shed light on the paleoecology and taphonomic histories of early Pleistocene faunal assemblages, including those from the archaeo-paleontological sites in Beds I and II of Olduvai Gorge.

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A Taphonomic Study of Tortoise Remains from the Later Stone Age (LSA) in the Kasitu Valley, Malawi

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The remains of small, sessile fauna at archaeological sites may indicate broad dietary subsistence patterns in ancient societies. Turtle and tortoise (Testudinae) remains from Later Stone Age (LSA) sites are typically reported as simple counts, rather than with full taphonomic and zooarchaeological analysis. This hinders an understanding of their role in hunter-gatherer diets, as they may have been accumulated by non-anthropogenic means. This study provides an analysis of testudines from four sites in the Kasitu Valley in Malawi that span the last ~30,000 years and situates it with what is presently known about the accompanying large mammal fauna. The assemblages show varying patterns of anthropogenic modification and density of testudinae remains, with a preponderance of remains dating to Holocene layers. Anthropogenic modifications are mainly in the form of burning and cut marks, and at least two taxa are represented. This project has enhanced our understanding of small game utilization, which complements the more common analyses of large game exploitation.

PyLithics: A Python Package for Stone Tool Analysis

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For over one hundred years, archaeologists have recovered, recorded, photographed and drawn stone tools, and used these to build up strong models of their typologies, technologies, distributions, and affinities. Much of this information is recorded in publications of greater or lesser accessibility, and large-scale, comprehensive databases are few and far between. To improve the scale and quality of these data, the PALAEONALYTICS Project has utilized computer vision methodologies to develop *PyLithics*, an open-source, free for use, software package to capture rapidly large volumes of these data in usable forms. *PyLithics* v1.0 processes lithic artifact illustrations scanned from the literature and has been optimized for feature extraction and measurement using a number of computer vision techniques, including pixel intensity thresholding, edge detection and segmentation, and custom template matching and image kernels. On

both conventional and modern drawings, *PyLithics* v1.0 can identify and measure dorsal surface scar number, shape, size, orientation and diversity. The orientation and flaking direction of dorsal scars can also be calculated from either ripples or arrows. Complete size and shape metrics of individual scars and whole flakes can be calculated and recorded in a customizable database. The resulting data can be used for metrical analysis, extracting features indicative of both typologies and technological processes. Data output has been optimized for machine learning and neural network processing algorithms and can easily be employed to explore patterns of variation within and between assemblages. Here, we describe these methods, show how researchers can access *PyLithics* for their own drawings, and outline briefly how these can be used to enhance current approaches to prehistoric lithic analysis. We then present results of the application of *PyLithics* to a Middle Stone Age assemblage from West Turkana, Kenya.

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The Aterian Hominin Fossils from Contrebandiers Cave, Morocco: A Study of Morphological Continuity in Northern Africa

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Northern Africa has yielded hominin fossil remains spanning the last million years, including the oldest currently know members of our lineage from Jebel Irhoud, Morocco. Such a temporal range allows us to explore regional continuity within Northern Africa, a geographic area which likely acted as a hub for hominin interaction and expansion of our species within and out of Africa. In this study, we report on the hominin fossil remains from the site of Contrebandiers Cave (Morocco). This site has been intermittently excavated since 1955, yielding a mandible, cranial fragments and, most recently (2009), a skull and partial juvenile skeleton of a 7- or 8-year-old child. These hominins are dated to around ca. 111 ka and are associated with the Aterian industry, a technocomplex found exclusively in North Africa. We use three-dimensional semilandmark geometric morphometric methods to quantify the mandibular and facial shape of the adult Contrebandiers mandible and juvenile maxilla and compare them to an extensive sample of Africa and Eurasia Pleistocene hominins. To address morphological continuity in the North African fossil record, we compare the Aterian *Homo sapiens* from Contrebandiers Cave, Dar es-Soltan, and El Harhoura to those preceding (Tighenif, Thomas Quarry, Jebel Irhoud, and Rabat) and post-dating (Iberomaurusian) them. Multivariate regression analysis was used to predict the adult shape of the juvenile face by growing it along three ontogenetic trajectories—Neanderthal, early *H. sapiens*, and Holocene *H. sapiens*, and the resulting juvenile and adult shapes were plotted in principal component analyses. This study supports previous research on North African Aterian hominins linking them to both the Middle Pleistocene fossils from Jebel Irhoud and early *H. sapiens* from Israel. In particular, the fossils from Contrebandiers support regional continuity in North Africa and an accretion of modern human mandibular traits through time.

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Long Durations and Low Temperatures: Detection of Prolonged Heating in Experimentally Burnt Bone Exposed to Air

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Ethnoarchaeological documentation of fire use in hunting and gathering modern societies has highlighted the variable of duration as a distinguishing factor between different functional roles of fires (Mallol et al. 2007). Duration of fire activity is therefore a valuable characteristic for reconstructing ancient fire use practices. In this present study we test the applicability of fauna to recognize long duration thermal alteration through a sequence of experimental trials utilizing bone cores (bovid femur and humerus cortical bone) burnt in a Nabertherm Muffle Furnace. Bone cores were heated exposed to air at temperatures above (750˚C) and below (300 and 550˚C) the inversion stage of bioapatite mineral alteration, or calcination, for periods of 10 minutes, 9 hours, and 48 hours, plus an extensive cooling period on heat retaining sediments (quartz sand and gravel), which mirrors the smoldering and extinguishing of actualistic fire events. Subsequent to burning, bone cores were analyzed with a RM200 CAPSURE Color Matching Tool, Fourier-Transform Infrared Spectroscopy (FTIR) with Attenuated Total Reflectance (ATR) attachment, and X-Ray Diffraction (XRD) to provide information on the degree of crystallinity of the bone bioapatite crystals as well as structural and compositional changes attributed to different temperature thresholds. Results indicate that coloration, a primary characteristic utilized by zooarchaeologists to record information about burning intensity (e.g., Stiner et al. 1995), is not an exclusive indicator of high temperatures. We show here that whitening of the bones may be achieved both by high temperatures and prolonged heating, as coloration changes present a response to the alteration and removal of the organic bone components. Changes in bone crystallinity and bioapatite sizes, however, remains a reliable indicator

of high temperature intensity and is visible with spectroscopic testing. Combined, this study provides macroscopic and spectroscopic methodological recommendations for recognizing and testing for low temperature and long duration archaeological fires.

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Application of Adhesives and Paints in the Middle and Upper Paleolithic (Based on Materials from Mezmaiskaya Cave, Russia)

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Modern research methods determine micro-remains of organic substances on surfaces of Paleolithic artifacts. Our research has allowed obtaining new information about technologies of Paleolithic humans in the North-Western Caucasus. The residue analysis conducted on the Middle Paleolithic artifact from Mezmaiskaya cave indicated that adhesive mastics were used for hafting lithic tips to shafts to create stone-tipped projectiles. The IR spectroscopy defined that these mastics contain three types of organic matter residues—bitumen, wood resin, and animal protein. The presence of bitumen was also confirmed by microscopy studies in transmitted polarized light. The wood resin remains found on a bifacial scraper indicate that this resin was also used for hafting the tool in a haft. Complex composite paints that were used for coloring were identified on the Upper Paleolithic decorations from Mezmaiskaya cave. The paints' composition includes wood resin/bitumen, as well as ochre and clay. The especially important finding is the identification of animal glue in these paints. This is because the animal glue is the artificial product, the production of which requires special technologies, unlike the wood resin/bitumen, ochre, and clay, which can be found in their natural sources.

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Seasonal Carbon and Oxygen Isotope Compositions from Lomekwi in the Turkana Basin, Kenya

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We report seasonal $\delta^{13}C$ and $\delta^{18}O$ values from bovids and hippos from the Lomekwi paleontological collecting area, spatiotemporally near Lomekwi 3—the earliest known site of hominin stone tool production dated to 3.3 Ma—and Kalokodo (1.7 Ma) in Turkana, northwestern Kenya. Samples were diced from the teeth of two alcelaphini, two antilopini, and two hippotragini teeth for enamel carbonate stable isotope analysis. Increased $\delta^{13}C$ from Lomekwi (-0.5±0.7‰ 1 S.D., VPDB scale, n=95 measurements) to Kalokodo (2.4±0.8‰, n=132) are consistent with regional aridification across the Plio-Pleistocene transition. This result is supported by increased alcelaphini $\delta^{13}C$ values from Lomekwi (-0.7±2.1‰) to Kalokodo (3.6±0.8‰), and with behavioral differences between two sampled Lomekwi antelopini ($\delta^{13}C$=0.5±0.8‰) and two Kalokodo hippotragini (1.8±1.1‰). We find similar mean $\delta^{18}O$ values and ranges among alcelaphini at both sites, but lower mean $\delta^{18}O$ values and higher $\delta^{18}O$ variation among Kalokodo hippotragini (28.4±1.1‰, VSMOW) compared to Lomekwi antilopini (30.8±0.5‰). To better evaluate Lomekwi $\delta^{18}O$ seasonality, we acquired 112 sensitive high-resolution ion microprobe (SHRIMP) $\delta^{18}O$ values from the innermost enamel of two hippos from near Lomekwi 3. Within a narrow depositional sequence, both hippos record different seasonal $\delta^{18}O$ patterns, with lower mean $\delta^{18}O$ values (18.5‰) and $\delta^{18}O$ ranges (3.3‰) in one hippo, and higher mean values (20.2‰) and ranges (4.6‰) in another. These data suggest differing seasonal rainfall regimes consistent with climate variability observed in lacustrine and deep-sea records across Milankovitch orbital cycles. We show how a portion of environmental variation inferred from carbonate $\delta^{18}O$ variation (1.7–3.7‰) can be recovered using inverse modeling.

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Modeling Stone Tool Raw Material Procurement around Sehonghong Rockshelter in the Eastern Lesotho Highlands

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Stone tools provide some of the best remaining evidence of human behavioral change over time and space. However, raw stone materials are costly to procure on account of their weight and unpredictable distribution within the landscape. This study seeks to address the central question of how prehistoric peoples managed these challenges of sourcing and moving stone raw materials. As a case study, we present one of the first systematic stone raw material surveys in Lesotho, centered on the rock shelter of Sehonghong. Lesotho has one of Africa's richest Stone Age archaeological records and lies within a montane environment unique to South Africa, but past research has yet to address the role this environment played in how prehistoric peoples moved and managed stone resource procurement strategies. A systematic landscape survey around Sehonghong was conducted using a random sampling strategy to account for survey bias. For any random 5mx5m unit within 3km of Sehonghong that contained greater than 100 nodules, the shape, size, and texture were recorded for different stone types. This raw stone distribution is then compared to an archaeological assemblage from Sehonghong, encompassing the transitional period of the Last Glacial Maximum. Using this comparison, we quantify the fit between stone distribution in the landscape and what was actually collected and deposited by people at Sehonghong. Results from statistical analyses in R suggest 1) preferential foraging within a local (1–3km) versus hyperlocal (0–1km) radius around Sehonghong, 2) directed procurement of cryptocrystalline materials like chert over more locally abundant and available lithics such as dolerite or sandstone and, 3) shifts in raw material management at Sehonghong through time with deeper implications for shifting mobility patterns. These results contradict previously held hypotheses of resource management in this region and further our understanding of the role montane environments play in resource procurement.

The Roof Has Fallen: An Actualistic Experiment to Characterize the Taphonomic Signature of Roof Fall

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Over 50 years of research has highlighted the important role of hominins and carnivores play as agents of bone fragmentation. Work has largely been focused on differentiating the assemblages created by hominins from those modified by carnivores. Consequently, cave roof fall and other agents have received relatively little attention in this rich literature. Previous studies of roof fall have suggested it can modify assemblages in a manner that mimics hammerstone-on-anvil percussion of bones indicating the need for reliable criteria to distinguish between these two processes. Here, we conduct an actualistic experiment designed to simulate the effects of roof fall on bone assemblages. Sixteen bison tibiae were fractured in four experiments with drop heights of 4.6 and 7.6 meters and rock weights of 6.8 and 13.6 kilograms. To represent a hominin assemblage, 16 tibiae were randomly selected from a hammerstone-on-anvil collection created by Robert Kaplan and stored at Colorado State University. Bone surface modifications (BSM) counts that include pits, notches, grooves, and striations were created for both groups. Additionally, notch measurement ratios, incipient flake counts, fragment counts, general fragment size counts, and epiphyseal fragment measurements were collected from both groups. A generalized liner model was used to analyze each variable between the roof fall dataset and the hammerstone-on-anvil percussion dataset. Results suggest a difference between roof fall and hammerstone-on-anvil percussion. The results from this study could be used to separate the taphonomic signature of roof fall from hammerstone and anvil percussion in archeological sites. This could allow for a better understanding of hominin behavior by diminishing the chance that a roof fall made assemblage will be mistaken as a hominin-made assemblage.

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Measuring the Computational Complexity of Artifact Design in Paleolithic Archaeology

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Originally conceived by Herbert A. Simon (1916–2001), *formal design theory* (FDT) was developed in engineering science in the decades after World War II as a systematic and quantitative approach to the creative process of artifact design (Simon 1969). Its development was driven largely by application of software programs to the design process and influenced by the simultaneous development of approaches to *evolutionary computation* (e.g., De Jong 2007): artifact design is a "non-deterministic, iterative, evolutionary process" that requires a *heuristic search* for a problem solution among a potentially wide range of alternative possible designs (e.g., Braha and Maimon 1998). We propose that FDT may be applied to the design of artifacts in hunter-gatherer societies, including those of the remote past. Despite significant differences in materials and production, we suggest that the process of artifact design among hunter-gatherers is fundamentally similar to that of complex and even modern industrial societies (i.e., "trial and error" or heuristic search). The most important contrast between hunter-gatherer and complex societies lies in the absence of design aids such as written mathematics

and computer software among the former. Application of FDT to artifact design among hunter-gatherers prompts us to consider the process according to a structured, abstract representation that is amenable to standard measures of computational complexity, which include *time complexity* (number of steps) and *space complexity* (amount of memory storage) (e.g., Papadimitriou 1998). Significant increases in the computational complexity of the design process occur when the structural or "hierarchical complexity" (Hoffecker and Hoffecker 2018; Simon 1969) of the optimal design solution expands, because the number of alternative possible designs increases exponentially (i.e., the size of the "search space" increases by an orders of magnitude) with the number of organizational levels. At least two expansions of hierarchical complexity in artifacts are recognized in Paleolithic archaeology.

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Landscape Connectivity and Hominin Movement in Late Pleistocene Central Asia

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The foothills of the Inner Asian Mountain Corridor (IAMC) in Central Asia provide key niches for hominins during periods of climatic change and deterioration during the late Pleistocene. This high-elevation range starts in the SW corners of Uzbekistan and Tajikistan and terminates in the Altai Mountains in Russia. The IAMC provides both refuge during climatic downturns as well as potential pathways that connect the western and eastern landscapes that juxtapose the Tien Shan and Altai Mountains. Genetic and archaeological evidence suggests that Neandertals, Denisovans, and modern humans shared these landscapes, as well as mates. Our exploratory study investigates the potential patterns of hominin movement in this broad and heterogenous region. Possible travel pathways may be inferred by analyzing the landscape's potential connectivity using factors that reflect the cost of movement. The connectivity among well-known archaeology sites in Central Asia and the surrounding regions, including Teshik Tash, Obi-Rakhmat, and Denisova Caves, were examined here. Least-cost path and corridor analyses were conducted in R with several landscape variables such as slope, elevation, and elevation variation, in order to create a resistance map that simulates hominin movement costs. Understanding the patterns of connectivity in this region allows us to better reflect on how 'obstacles' to hominin movement are characterized. When obstacles, like high mountains and deserts, are reframed as permeable and productive landscapes, valid descriptions of the limits of hominin adaptation, niche preference, and potential areas of population overlap and mate exchange are possible.

Ostrich Eggshell and Giant Land Snail: Food, Ornaments, and Environmental Indicators in the Late Pleistocene and Early Holocene of Malawi

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Little is known about the evolution of human-environment interactions in the Zambezian Biome (ZB) of southeastern Africa. Paleoenvironmental proxies from lake cores document reduction in Afromontane and tropical forests across the Pleistocene-Holocene transition, in favor of grasslands and Zambezian woodlands. Grasslands are the favored habitat of ostrich (*Struthio* spp.), which are absent today across most of the ZB. However, ostrich eggshell (OES) fragments from two archaeological sites, Hora-1 and Mazinga-1 (northern Malawi), show consistent presence in the terminal Pleistocene, followed by a sharp decline in density before disappearing from securely dated Holocene layers. As OES vanishes, giant land snail (LSS) fragment density increases. Late Pleistocene beads were produced using OES, while Holocene beads were produced using LSS. The timing of these changes suggests that the environment had significant impacts on suitable ostrich habitats, and subsequently on the foragers exploiting them, compelling them to seek alternate resources for food and/or ornament manufacture. Alternatively, human exploitation may have hastened ostrich extirpation, or hunter-gatherers may have routinely traded OES in this part of the ZB mainly during the Pleistocene. We provide a taphonomic assessment of these hypotheses, tested against alternative hypotheses that changes in the accumulator or other taphonomic variables better explain this pattern.

Correlated Responses or Divergent Evolution: Perspectives on Hominin Canine Evolution

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Relative to extant African apes, hominins are characterized by smaller, less dimorphic canines. Though this pattern is well documented in the fossil record, considerable debate continues about the selective pressures that drove such changes. For example, are the canines genetically coupled with other aspects of the dentition? Does canine size in males and females evolve independently or are the sexes

constrained to evolve together (i.e., a correlated response)? To contextualize canine size reduction in hominins, we examined rates of maxillary canine height evolution in a broad swath of extant primates (68 extant species and 5 extinct hominins) with three goals in mind: 1) to see if male and female primate canine size evolves at different rates; 2) to compare rates of canine size evolution among primate clades; and 3) to model whether male and female canine size evolves independently among species. Models were calculated for each sex and compared to identify locations along the phylogeny where the rate of canine evolution changed and where patterns differ between males and females. Across primates, male canine size evolves more rapidly than does female canine size. Additionally, several likely locations were identified where selection on male and female canines appears to diverge. Cercopithecines, especially papionins, showed the greatest difference in the rate of evolution between males and females, though differences were detected within hominids and throughout the phylogeny. These results suggest that for primates, particularly catarrhine primates, canine evolution has largely been independent between the sexes and that a correlated response to evolutionary pressures in the other sex is not expected. The reduction in hominin canine size and loss of canine sexual dimorphism likely began with the rapid reduction of male canine size early in hominin evolution with subsequent reduction in canine size in both sexes continuing throughout hominin evolution.

Fossil Macaque (Cercopithecidae, Primates) Specimens from the Megalopolis Basin Middle Pleistocene Deposits, Greece

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The Megalopolis basin (Peloponnese, Greece) is known for its Pleistocene fossiliferous deposits. The basin's stratigraphic sequence comprises fluviolacustrine deposits containing lignite seams and spans from ca. 900 ka to ca. 150 ka, thus covering part of the Early and the entire Middle Pleistocene. Since 2012 the basin has been investigated for stratified lithic and faunal remains by a joint team from the Ephorate of Paleoanthropology & Speleology (Hellenic Ministry of Culture), the University of Tübingen Paleoanthropology group, and the Wiener Laboratory (American School of Classical Studies at Athens). This field work resulted in the identification of several new paleontological localities, as well as evidence of early human presence dating to at least as early as the Marine Isotope Stage 12. Here we report on two new fossil *Macaca* specimens—an almost complete mandible (MAR-1-9B) from Marathousa-1, dated at 500–400 ka and an isolated upper molar from the stratigraphically older Kyparissia- 4. Both sites have also yielded stratified lithic artifacts. Comparative metric analysis of the teeth permits the attribution of both specimens to the Barbary macaque, *Macaca sylvanus*, a species that was geographically widely distributed in western Eurasia during the Plio-Pleistocene. MAR-1-9B is attributed to *M. s.* cf. *pliocena* and represents an older male individual of ca. 13kg body mass (Konidaris et al. 2022). The Kyparissia-4 molar also fits better with fossil *Macaca sylvanus* samples, but its taxonomy cannot be ascertained further. MAR-1-9B represents the most complete fossil European macaque mandible, while together the Megalopolis specimens greatly enrich the sparse *Macaca* record in the eastern Mediterranean region. They also constitute the first evidence of macaques in the Middle Pleistocene of Greece, and document for the first time the coexistence of macaques and hominins in this region.

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Preliminary Lithic Technological Analysis of Solak-1, an Open-air Upper Paleolithic Site in the Armenian Highlands

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While research into the Middle Paleolithic of the Armenian Highlands has increased our understanding of the prehistory of this region, the Upper Paleolithic remains poorly understood. The open-air site of Solak-1 represents the third known stratified Upper Paleolithic site in Armenia. Excavated in 2015, an obsidian-rich lithic assemblage was recovered from six sedimentological horizons. The deposits are estimated to date between 30–20 ka, due to their assumed technological affinities with the Middle-to-Late Upper Paleolithic, but the site is not presently directly dated. For this study, the lithic assemblage was subjected to a techno-typological attribute analysis. Preliminary results reveal a heavily fragmented and damaged bladelet-dominated assemblage. Retouched tools are primarily backed and retouched bladelets, in addition to endscrapers, burins, truncations, and retouched flakes. The recovery of several bladelet cores and a plethora of micro-debitage make it likely that at least some reduction occurred on site, although cores for large blanks are

absent or heavily reduced. Additionally, pXRF analysis of 1,166 obsidian pieces documents long distant transport or exchange of at least 250 kilometers. Initial comparisons to Aghitu-3 Cave and Kalavan 1, the only two published Upper Paleolithic sites in Armenia, suggest that the Middle-to-Late Upper Paleolithic in the region is broadly characterized by unidirectional bladelet—and to a lesser extent, blade—technologies, with retouched toolkits dominated by backed and retouched bladelets. Metrically and technologically, the Solak-1 bladelets are most comparable to those from Aghitu-3 archaeological horizon III, dated to 29–24 ka cal BP. The range and distance of obsidian sources identified at Solak-1 is also most comparable to Aghitu-3 AHIII, further suggesting such a comparison and a pre-Last Glacial Maximum age for the Solak-1 assemblage. This research adds to our understanding of *Homo sapiens* mobility and technological practices during the Late Pleistocene in the Armenian Highlands and southern Caucasus.

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Technical Considerations for Observing, Documenting, and Interpreting Feeding Traces in the Fossil Record

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Feeding traces preserved in the fossil record represent direct evidence of consumer relationships in the past. However, the exact nature of the information stored within traces such as tooth marks remains poorly constrained. Taphonomic equifinality conflates the patterns and morphologies of physical traces on the bone surface, often preventing accurate determination of the taphonomic agent. Without a robust framework for interpretation, taphonomic studies are plagued by subjectivity, and many interpretations are not translatable across measurement techniques. Actualistic experiments have attempted to constrain feeding trace morphology against known taphonomic controls. These have been met with challenges and most conclusions are still accompanied by uncertainty. Nevertheless, important strides have been made in defining both individual mark morphology and overall bone surface modification patterns. The contemporary view is that a wholistic evaluation of the entire assemblage is needed to clarify the interactions represented at a specific site. Here we examine a sample of modified bones obtained from the controlled feeding of Nile Crocodiles (*Crocodylus niloticus*). We provide a comparison of macro-, meso-, micro- and ultramicroscopic measurements, including both optical and non-optical techniques. In this presentation we demonstrate the limitations of each methodology to determine the most informative, efficient, and cost-effective means of viewing and documenting feeding traces on animal bones. Ultimately, we show how physical differences between samples can affect interpretations. While each technique provides valuable information, optical microscopy can be used to quantify the internal morphology of a trace at high resolution, while largely avoiding potential sources of distortion associated with higher levels of magnification. This technique also allows for easier manipulation of the specimen and contextualization of observations within the larger pattern of bone surface modification across the skeletal elements.

Paleoenvironmental Reconstruction of Gona, Ethiopia Between ~3–1 Ma Using Stable Carbon and Oxygen Isotopes

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Stable carbon and oxygen isotope data from 303 mammalian fossil enamel samples were collected and analyzed from sediments between ~3–1 million years ago (Ma) from Gona, Ethiopia. This time period spans the origin of our genus *Homo*, evolution of *Homo erectus*, and the increase of complex behaviors including the advent of the Oldowan and Acheulian stone tool technologies. These important evolutionary milestones have long been hypothesized to coincide with grasslands in Africa. Gona has among the longest continuous record of Early Stone Age archaeology in eastern Africa, including some of the earliest Oldowan and Acheulian assemblages, and abundant paleontological deposits (Caceres et al. 2017; Dominguez-Rodrigo et al. 2005; Semaw et al. 1997; 2003). Thus, these data allow for testing environmentally driven evolutionary hypotheses. Stable carbon and oxygen isotope data from fossil enamel have been used as proxies in paleoenvironmental reconstructions to provide context important for understanding human evolution. These data reflect the proportions of C_3 (trees, bushes, and shrubs) and C_4 (grasses and sedges) resources in an animal's diet ($\delta^{13}C$) used to reconstruct habitat, as well as surface drinking water, or water in the animal's food ($\delta^{18}O$), which can be used to estimate water availability. Data were compared spatiotemporally through four geological units, by archaeological or paleontological significance, and regionally to a large contemporaneous dataset (n=2,481). The results indicate a range and variety of environments existed at Gona throughout all time units, though predominately composed of C4 resources and more enriched than contemporaneous localities. Statistically significant increases in C_4 and $\delta^{18}O$ between units and contemporaneous fossil localities provide evidence for heterogeneity in the East African Rift Valley, the importance of C_4 resources (or the animals consuming them) to human evolution, and suggest a possible behavioral shift in hominins around ~2 Ma.

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A First Look at the LSA Lithic Assemblage of KLT-1 (Gona, Ethiopia)

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The Gona study area is known for its rich paleontological and archaeological record, including some of the earliest stone tools and hominin fossils. The more recent paleoanthropological record at Gona is less known. In particular, the Later Stone Age (LSA), a period witnessing the long-distance spread of many cultural innovations, remains poorly documented, reflecting a general paucity of sites in the broader LSA cultural landscape of the Afar region. To address this issue, the Gona Project conducted extensive fieldwork in the southwest parts of its study area in 2018–2020, leading to the discovery of multiple clusters of LSA localities. Here we present some preliminary observations on the lithic assemblage of KLT-1, a site dated to 14–11 ka based on radiocarbon measurements. A 2m x 2m pilot excavation reached 15cm in depth, yielding approximately 5,400 *in situ* knapped pieces, in addition to ground stones, ostrich eggshell beads, and animal bones. The assemblage is dominated by obsidian, typically bearing a naturally weathered surface; one of its potential sources (Fursa/Ire Deti) is 15km north of the site. The extreme abundance of chips (38.1%) suggests that intense knapping activities occurred locally, and one can identify a major reduction sequence of bladelet production through the high frequencies of bladelets (28.4%), compared with flakes (13.5%) and blades (1.5%). This trend can also be inferred from cores, as 45 out of 47 cores bear at least one bladelet scar. The secondary modification of bladelets displays some rather unique features as: 1) all retouched bladelets (n=82) are non-geometric microliths and 2) backing (abrupt retouch) is rather infrequent (17.1%). Our future research will include data from adjacent localities in the Kilaitoli drainage and focus on both intra-site and inter-site core variability to understand better the land-use strategies of LSA Gona foragers and their social connectivity to the broader region.

Terrestrial Signal in the Forelimb of OH 36 (*Paranthropus*) and TM-266 (*Sahelanthropus*) Questions Their Bipedal Status

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The ulna of extant apes is distinct from other anthropoids, with knuckle-walking engendering a unique degree of robusticity and curvature in the African apes. Here we use Fourier shape descriptors to compare ulna contours in a sample of 418 extant primates from 88 species against 16 fossil ulnae from *Sahelanthropus*, *Ardipithecus*, *Australopithecus*, *Paranthropus*, and *Homo*. We find that fossil hominin proximal ulna shape likely reflects the ancestral ape form, allowing for a range of locomotor postures and enhanced manipulative abilities. Trochlear notch retroflexion in African apes and modern humans appears to be homoplastic since it is absent in earlier hominins, potentially related to knuckle-walking in the African apes, and maximizing velocity and reducing elbow joint torques in throwing in modern humans. The proximal ulna of *Ardipithecus* infers a versatile elbow joint capable of a broad range of locomotor postures including suspension, in agreement with recent evidence for other suspensory adaptations. Except for the TM-266 *Sahelanthropus* and OH 36 *Paranthropus boisei* fossils, the ulna shafts of early hominins appear to be functionally unspecialized, falling within the shape space of humans, *Pongo*, and terrestrial quadrupedal monkeys, indicating the potential for a versatile range of postures and behaviors. Interestingly, our results place the *A. afarensis* and *H. floresiensis* ulnae closest to humans among the hominin sample. By contrast, the OH 36 and TM-266 appear to signal a specialized forelimb unlike all fossil hominins and modern humans, raising questions about their bipedal status. Neither climbing nor allometry can explain the extreme curvature and *Pan*-like morphology of these fossils, which instead results from the support and propulsion roles *of m. flexor digitorum superficialis* and *m. flexor carpi ulnaris* during terrestrial locomotion. Rather than representing fossils of obligate bipeds, their distinctive similarity to *Pan* may provide evidence for habitual use of the forelimb in terrestrial locomotion.

Landscape Level Vegetation Study in Modern African Ecosystems: Implications for Hominin Environments

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The link between climate change and human evolution is one of the major issues raised in human evolutionary studies. A primary means by which climate is thought to influence human evolution is through alteration of the vegetation structure of hominin habitats.

Vegetation on a landscape provides key ecosystem services and vegetation dynamics in the past are thought to be closely tied to major evolutionary adaptations in the hominin lineage. A clear understanding of vegetation composition and distribution on landscapes in modern African ecosystems, and how this composition is related to the proxies available in the fossil record, are a critical step in making accurate reconstructions of hominin landscape dynamics. To this end we conducted a landscape-level spatial analysis of vegetation patterns in selected modern African ecosystems that range from forests to open savannas. We used published landcover classification to compute total areal cover and number of patches for each vegetation type in each ecosystem. To explore the relationship between vegetation distribution and herbivores in these ecosystems, we compiled data on the relative abundance and diet of herbivores inferred from carbon isotope studies. While most vegetation types (e.g., closed forests, open woodlands, shrublands and grasslands) are available across the ecosystems examined, we observe differences in their areal cover. Analysis of the number of patches of each vegetation type across these ecosystems also shows that despite having a smaller total areal cover, some vegetation types such as grasslands can consist of numerous smaller patches. When comparing the proportion of browsers, mixed feeders and grazers weighted to the herbivore relative abundance, a higher proportion of grazers is observed in most ecosystems than would be predicted based on the areal extent of grasslands. This study has significant implications for paleo-landscape reconstructions and recommends caution in interpreting the herbivore fossil record and hominin environments.

Reconstructing the Paleohabitat of Pliocene Hadar Hominins Using Bone Surface Modification Analysis

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Bone surface modification analysis provides significant insight into Plio-Pleistocene prey and predator interactions, as well as paleoecological and depositional environmental conditions, yet it is an underutilized proxy. Previously, oxygen isotopes, pollen, and faunal turnover models have been applied as proxies to investigate the paleohabitat and depositional environment of Pliocene Hadar hominins. The Pliocene Hadar Formation, deposited ca. 3.8–2.9 Ma in Afar, Ethiopia, has produced spectacular hominin fossils including AL.288-1. Here, we introduce a new approach to reconstruct the paleohabitat based on analysis of carnivore tooth marks on the bone surfaces of Suidae specimens from three members of the Hadar Formation—Basal Member (BM, ~3.45–3.42 Ma), Sidi Hakoma Member (SH,~3.42–3.24 Ma), and Denen Dora Member (DD, ~3.24–3.20 Ma). Of 476 mandible and crania specimens, 54% bear bisected tooth marks, exclusively associated with crocodilian modification. Crocodiles have a specific preference for aquatic areas and the abundance of crocodilian tooth marks suggests a restricted paleoecological setting, which can be used to infer the broader paleoecological conditions of the period. Fifty-seven percent of bisected tooth marks are found on the specimens from SH, and of the three genera of Pliocene Hadar Suidae (*Kolpochoerus*, *Notochoerus*, and *Nyanzachoerus)*, the bone surface of *Nyanzachoerus* was most extensively modified by *Crocodylus*. These results suggest that this genus might have lived close to the aquatic landscape and that more wetland and aquatic habitat was present in Hadar during the time of deposition of SH. Drier or intermediate conditions may have persisted before and after this time since abundant crocodilian marks are not observed in specimens from BM or DD. These findings are also relevant for the Pliocene hominins, who may have experienced a lacustrine-based paleoenvironment during SH deposition.

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Serial Sampled Equid Enamel as a Window on Final Middle Stone Age Seasonality at Sehonghong Rockshelter, Highland Lesotho

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Understanding seasonal shifts in hunter-gatherer subsistence and settlement is critical to interpreting the deep time archaeological record at the scale of lived experience. Seasonality, however, remains an elusive climatic parameter. Some insight into these patterns can be gleaned from isotopic analysis of faunal tooth enamel, which provides an archive of dietary and environmental conditions ranging from daily/weekly increments to months or years. To systematically assess environmental and resource variability, standardized sampling procedures that use detailed histological sections to guide isotopic sampling are necessary. Tooth histology and enamel growth patterns and rates should be linked to the location of isotopic samples, so that the time of enamel mineralization is well constrained relative to other samples from the tooth and within the life history of the individual. This study applies a method for interpreting intra-tooth isotopic variability as a proxy of past seasonality to equid teeth from the final Middle Stone Age (MSA) levels at Sehonghong Rockshelter, highland Lesotho. The method was developed by using a model of equid tooth mineralization to analyze the serial enamel isotopic composition of a modern assemblage of zebra and corresponding results with contemporaneous precipitation data from Ol Pejeta Conservancy in Kenya. Sehonghong equid enamel was serially sampled for oxygen ($d^{18}O$), carbon ($d^{13}C$), and strontium ($^{87}Sr/^{86}Sr$) isotopes to obtain a comprehensive picture of annual migratory behavior and associated seasonal hunting practices of Afromontane foragers during the final MSA.

Is *Paranthropus boisei* an Environmental Specialist Compared to Early *Homo*? Evaluating Faunal Evidence from the Koobi Fora Formation, Kenya

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Since the discovery of *Paranthropus boisei* alongside early *Homo* at Olduvai Gorge and East Turkana, paleoanthropologists have attempted to understand the different evolutionary paths of these two hominin lineages since their divergence in the Pliocene. Conventional wisdom is that their prolonged phase of sympatry in eastern Africa reflects very different adaptive strategies, with early *Homo* characterized as the ecologically flexible generalist and *Paranthropus* as the less versatile specialist. If correct, this should imply differences in their use of ancient landscapes, with *Homo* occurring in a broader range of environments compared to *Paranthropus*. In this study, we use the fossil record of large mammals from the Koobi Fora Formation dated to 2.0–1.4 Ma to quantitatively evaluate the ecological breadth of faunal assemblages associated with *Homo* and *P. boisei*. We also evaluate the more common mammal genera to determine where each falls on a spectrum of generalist to specialist with regard to environmental associations. Results suggest that both *Homo* and *P. boisei* are associated with faunal assemblages representing most of the environmental variability in the Koobi Fora Formation, implying that the key ecological difference between these taxa concerns diet rather than environmental associations.

Evaluating the Reliability of Lithic Technology for Detecting Prehistoric Migrations

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Archaeologists often use similarities in lithic artifacts to infer hominin population expansions and interaction. However, it is unclear at what spatio-temporal scales convergence is a more likely explanation of similarity than shared history. To explore whether similarity in lithic technology is a reliable indicator of shared history between archaeological groups at different spatio-temporal scales, we perform two case studies where we may trace technological change across migration events where we know the population histories and cultural relatedness of archaeological groups *a priori*—the migration of Ancestral Puebloan groups from above to below the Colorado Plateau in the American Southwest between 700 and 600 BP, and the spread of Austronesian speakers across Oceania between 3500 and 500 BP. We also developed a model of the expected level of technological similarity in the absence of cultural relatedness by analyzing a global dataset of flintknapping techniques (n=80 assemblages) and technological modes (n=1,126 assemblages) spanning Africa, Eurasia, Oceania, and the Americas. In the American Southwest, we found migrants and their ancestors were unusually similar technologically compared to the global model, which is consistent with their shared history. In Oceania, Austronesian speakers were closer to the expected level of technological similarity generated from our global model, which reflects their adaptation to diverse environments across many generations. In the Austronesian case, groups rapidly changed their technologies to suit the different environments of islands across Melanesia and Polynesia, resulting in a mismatch between population history and technological similarity. These results help to clarify the spatio-temporal scales at which lithic technologies might be reliable as indicators of shared history and as migration markers in the archaeological record, as well as the phenomena that influence the strength of historical signal in technology.

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Bone Tools from Beds II-IV, Olduvai Gorge, Tanzania, and Implications for the Origins and Evolution of Bone Technology

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The advent of bone technology in Africa is often associated with behavioral modernity that began sometime in the Middle Stone Age. Yet, small numbers of bone tools are known from Early Pleistocene sites in East and South Africa, complicating our understanding of the evolutionary significance of osseous technologies. These early bone tools vary geographically, with those in South Africa indicating use in foraging activities such as termite extraction and those in East Africa intentionally shaped in a manner similar to lithic tool manufacture, leading some to infer multiple hominin species were responsible for bone technology in these regions, with *Paranthropus robustus* assumed to be the maker of South African bone tools and *Homo erectus* responsible for those in East Africa. Here, we present on an assemblage of 52 supposed bone tools primarily from Beds III and IV, Olduvai Gorge, Tanzania, that were excavated by Mary Leakey in the late

1960s and early 1970s, but were only partially published and were never studied in detail from a taphonomic perspective. Our analysis confirms at least six bone tools in the assemblage, the majority of which are intentionally flaked large mammal bones. However, one of the tools is a preform of the oldest barbed bone point known to exist anywhere in the world and pushes back the initial appearance of this technology by 700 kyr.

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Testing the Social, Cognitive, and Motor Foundations of Paleolithic Skill Reproduction

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Stone tools provide key evidence of human cognitive evolution but remain challenging to interpret. Tool-making skill-learning has been understudied even though: 1) the most salient cognitive demands of tool-making should occur during learning, and 2) variation in learning aptitude would have provided the raw material for any past selection acting on tool-making ability. However, we know very little about the cognitive prerequisites of learning under different information transmission conditions that may have prevailed during the Paleolithic. This paper presents results from an exploratory study to trial new experimental methods for studying the effect of learning conditions and individual differences on Oldowan flake-tool-making skill acquisition. We trained 23 participants for two hours to make stone flakes under two different instructional conditions (observation only vs. direct active teaching). We employed appropriate raw materials, a moderate practice time duration, and in-person, fully interactive instruction. Participant performance was evaluated through an analysis of the stone artifacts produced. We compared performance across experimental groups with respect to individual participant differences in grip strength, motor accuracy, and cognitive function measured for the study. Our results show that 2 hours are insufficient to document learning-related performance change. However, teaching reduces variability in knapping rate, methods, and outcomes during early-stage learning, thus increasing the reliability of skill reproduction. Instruction also altered knapping quality vs. quantity trade-offs in the two groups and dramatically changed the effects of individual differences in strength, visuospatial working memory, and social learning tendencies on knapping outcomes. Our results provide further support for the hypothetical co-evolution of teaching, language, and tool-making, suggest that the presence/absence of instruction can fundamentally alter learning-related selection pressures on individuals, and offer lessons for the design of future experiments.

Tectonics and Vertebrate Diversity Patterns at Olduvai Gorge, Tanzania

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Climatic processes have been a primary focus in understanding the relationship between environmental change and hominin evolution in eastern Africa; however, the impact of tectonically driven processes on hominin evolution are less understood due to the difficulties in constraining local-scale tectonic processes. We aim to understand the impact of tectonically driven processes on vertebrate faunal communities by investigating Pleistocene paleoecological change at Olduvai Gorge, Tanzania. The Ngorongoro Volcanic Highlands (NVH) separates Olduvai Basin from the eastern branch of the EARS. This resulted in a closed basin with similar developmental properties as the EARS on a smaller spatial and temporal scale. We created a database of all published vertebrate fauna recovered that range in age from ~2 Ma, which is when extensional faulting began in the basin, to ~0.3 Ma. During this time there was syn-sedimentary faulting and NVH volcanic activity that had major impacts on the hydrology and paleolandscapes of the basin. We conducted various diversity analyses to understand change in vertebrate faunal communities through time. Rather than using the traditional stratigraphic subdivisions, we separated time into subsequent periods bounded by unconformities and/or eruptive events. We found diversity patterns are correlated with tectonically driven processes. Upper Bed I and lowermost Bed II had the greatest decrease in similarity, and are separated by deposition of Tuff IF, a large multi-eruptive volcanic event. Middle to late Bed II and Bed III had low similarity suggesting a gradual change in faunal community. Community evenness was also low during this time and drastically increased in Bed IV. Concurrently, there was ongoing fault and eruptive activity in the basin that ceased in late Bed III - early Bed IV times, indicating a relationship between tectonically-driven landscape change and the vertebrate faunal community.

Reconstructing Late Pleistocene Bison and Mammoth Ecology in Texas Using Stable Isotopes

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During the Late Pleistocene (LP; past 130,000 years), over two-thirds of large mammal (>45kg) species went extinct globally. While the role of humans is hotly debated, the effect of these extinctions is growing clearer; the extinctions resulted in widespread and lasting faunal community reorganization. However, the impact of these extinctions on dietary and migratory behavior within faunal communities is unknown. Our study examines the impact of the megafaunal extinctions on the dietary and migratory behavior of surviving *Bison* individuals in Texas using carbon, oxygen, and strontium isotopes. Strontium isotopes are incorporated into mammalian enamel during their tooth development and varies as these organisms travel to areas with new bedrock. To capture movement within an individual in the fossil record, serially sampling a single tooth can reveal the movements of an individual across space. Here, we examine the carbon, oxygen, and strontium isotopes from the enamel of two ubiquitous Pleistocene genera (*Bison* and *Mammuthus*) before the megafaunal extinctions. We preferentially sampled sites older than the commonly cited (12 Ka) date for widespread human occupation in North America. We also sampled *Bison* that survived the megafaunal extinction to compare migratory patterns before and after the extinction. This study thus presents high-resolution, serially sampled stable isotope data on bison (n=10) and mammoths (n=5) collected from five LP sites, dating from 33 to 11 Ka, in central Texas. Preliminary strontium isotope data suggest that *Mammuthus* has larger home ranges in Texas (>100km) than modern savannah elephants (30–50km). Our data will reveal important information about the effects of megafaunal extinction on migratory patterns through time. Given the small samples sizes of this study, additional research is needed to refine our understanding of the mechanisms causing this spatial and temporal variation and its relevance to other taxa.

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Facial Ontogeny in *Australopithecus afarensis*: Interpreting Variation and Its Implication for Early Hominins Phylogeny

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Taxon-specific facial traits and their variation are commonly used to interpret fossil hominin taxonomy and phylogeny. Yet, how these traits change through ontogeny and how that impacts our understanding of variation remain poorly understood even for relatively well-documented species such as *Australopithecus afarensis* (~3.7–3.0 million years ago). One of the limitations is the rarity of immature fossil hominins. Here, we investigate facial ontogeny and variation in *A. afarensis* for which recent fossil discoveries coupled with the application of novel imaging and reconstruction techniques have improved the juvenile sample size, which includes DIK-1-1 and A. L. 333-105. Specifically, we: (1) revisit and characterize facial morphology of the species to determine when species-specific traits are established through ontogeny and how they vary; (2) investigate facial shape changes and degree of variation in *A. afarensis* using geometric morphometric (GM); and, (3) compare the allometric scaling patterns between *Australopithecus* and *Paranthropus* in the context of great apes. The results show that overall juvenile facial morphology foreshadows adult morphology and despite their comparable age there are morphological differences between the juveniles to some extent mimicking variation seen in adults. However, there are facial regions where the species-specific features are not established by the time of dm^2 occlusion. Furthermore, GM-based evaluation of ontogenetic allometry among *Australopithecus* species shows high, size-related intra- and inter-specific variation mainly along the common growth trajectory. However, several shape differences between *Australopithecus* and *Paranthropus* cannot be explained by allometric scaling alone. In sum, our approach could provide a new perspective on interpreting early hominin taxonomy and phylogeny.

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Taming Nomenclature in Paleoanthropology

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Taxonomic names (nomina) play an integral role in communicating hypotheses of taxonomic diversity and phylogenetic patterns. Nomina have a complex history in paleoanthropology, in part reflecting dynamic changes in how we construe diversity in nature, as well as shifting theories about human origins in response to novel fossil discoveries and evolving theoretical paradigms. This paper reviews over 180 nomina invoked in human evolutionary studies from *Homo sapiens* Linnaeus, 1758 to *Homo bodoensis* Roksandic et al. 2021. We conducted a literature review of all nomina, their type fossils, and the related original publications. This information we compiled into a dataset using the Paleo Core platform. The compiled dataset features 187 nomina, 137 type specimens, and 770 publications. We

make these data available through the Paleo Core website and an Application Programming Interface (API) endpoint. The history of nomenclature in paleoanthropology is characterized by two discrete peaks of activity, the first spanning the early history of paleoanthropology from 1900–1968 during which 126 new names were proposed (including 9 new names in 1932 alone). This is followed by a gap from 1968–1975 after which another period of naming activity began, extending to the present. We reviewed the original source publications to assess the availability and validity of each name. From this we established a preliminary List of Available Names (LOAN) for eventual consideration by the International Commission on Zoological Nomenclature (ICZN). We propose establishing a committee comprising members of the Paleoanthropology Society and other relevant academic societies (e.g., ESHE, EAAPP) to further refine and ratify this list for adoption by the ICZN. Establishing a formal LOAN with the ICZN will help mitigate confusion regarding the use of some names and will also help remove conflicts with numerous pre-evolutionary names that were established around supposed "races" and subspecies of extant *Homo sapiens*.

By Any Other Name: Historical and Contemporary Trends in Fossil Hominin Nicknames

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The practice of nicknaming hominin fossils is alive and well in paleoanthropology, with at least seven new nicknames being coined in 2021 alone. In spite of its prevalence, however, the practice of nicknaming fossils has never been subjected to critical analysis in terms of what motivates it, its history, or detailing the factors that go into giving a fossil an identity in that way. This paper presents the first systematic review of hominin fossil nicknames to highlight historical trends in the practice of nicknaming fossils, with a discussion of their implications for how and why paleoanthropologists today give some fossils nicknames and what values currently underpin the choice of a nickname. We present an historical overview of this practice, which dates back to at least 1823, with the discovery of the 'Red Lady of Paviland' and highlight four cumulative phases—place-based monikers, classical references, Western pop culture, and local roots. While 'Lucy' is the most recognizable nicknamed fossil (with derived nicknames like 'Lucy's child', etc.), it appears that the practice accelerated beginning with the Leakeys during their fieldwork in the 1950s and 1960s. Since then, a few research teams driven by distinct motivations have generated most new fossil nicknames with the goal of bringing recognition to their site(s). We conclude with a discussion of why and how individual nicknamed fossils from less high-profile projects come to acquire their nicknames and what this says about the kinds of personas we develop for select human ancestors.

Developmentally-Informed Assessments of Diagenesis in Teeth

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Assessments of elemental chemistry in bones and teeth often employ laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) sampling of discontinuous spots or linear tracks, which may fail to identify precise changes in body chemistry during tooth mineralization, or diagenesis after burial. By contrast, mapping the entirety of tooth crowns and roots with LA-ICP-MS provides comprehensive longitudinal developmental records of dietary behavior, health, and neurotoxicant exposure. Analyses of the tooth chemistry of captive and wild nonhuman primates, as well as human children with prospective nursing and health records, reveal the nutritional and physiological experiences of individuals in unprecedented detail [1-3]. Despite a suggestion that calcium-normalized barium (Ba/Ca) patterns in teeth relate to dietary stress rather than dietary transitions [4], we have demonstrated Ba/Ca increases with the advent of milk intake and decreases with the cessation of nursing in multiple species. This pattern of element distribution in teeth is not substantially altered by mineral incorporation after secretion, yielding the first precise ages for the cessation of nursing (weaning) in Neanderthals [1, 5]. Here we show how whole-tooth maps are superior to conventional LA-ICP-MS approaches; they permit the comparison of developmental and elemental geometry in multiple tissues and across successive teeth, and reveal differential element-specific preservation and diagenesis [3, 5]. This is possible because biogenic elemental incorporation often mirrors the consistent and well documented geometry of tooth development, while diagenetic alteration typically shows a more localized diffuse pattern, particularly when multiple elements are considered in tandem [1, 5]. Such studies of trace element distributions from sections of recent human and hominin teeth offer a potent mechanism for the detection of diagenetic alteration at high spatial resolution, extending studies of ancient behavior and health further into the past.

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Environmental Change and Hominin Evolution: Building Stronger Links Through Understanding the Environmental Tolerances of Present-Day African Mammals

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A large body of paleoanthropological research proposes that changes in the biotic (e.g., vegetation) and abiotic (e.g., climate) environment influenced the evolutionary history of fossil hominins. Though hominin paleoecologists now have access to increasingly detailed records of late Cenozoic paleoenvironments in Africa, we have a limited understanding of: (i) which environmental variables were more likely to affect fossil hominins and (ii) the degree of paleoenvironmental change needed to elicit an evolutionary response. This makes it difficult to predict how (if it all) empirically observed paleoenvironmental shifts influenced fossil hominins (and other mammalian taxa), precluding the establishment of robust links between paleoenvironmental change and hominin evolutionary history. Following the foundations provided by Vrba's (1992) habitat theory, environmental change extending beyond a species' tolerance can lead to range shifts and vicariance, setting the stage for extinction and speciation. It follows that a better understanding of species' environmental tolerances is an important step towards establishing stronger inferences about macroevolutionary changes documented in the fossil record. Leveraging ensemble machine learning models, we examine how woody cover, annual precipitation, and precipitation seasonality relate to the probability of occurrence for 250+ species across 100+ present-day communities. By aggregating our results for different functional groups (e.g., arboreal browsers, terrestrial grazers), we can begin to predict the paleoenvironmental changes that were potentially important for macroevolutionary change in fossil taxa. We use our results to evaluate the hypothesis that the extinction of *Paranthropus boisei* was influenced by an increase in woody cover during the mid-Pleistocene transition. Our observations imply that exceptionally high increases in woody cover would be needed to drive its extinction.

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A Multiproxy Paleoecological Comparison of 2.8 Ma Hominin Sites

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While the hominin fossil record at 3.0–2.0 million years (Ma) remains sparse, evidence for hominin taxic diversity at this period is shown by the appearance of three species at ~2.8 Ma: *Australopithecus africanus*, *Paranthropus aethiopicus*, and early *Homo*. These fossils are found at Makapansgat, South Africa; Laetoli, Tanzania; and Ledi-Geraru, Ethiopia, respectively. Ecological conditions have not yet been compared at these sites. We reconstruct the likely habitats of these hominins using several proxies. We collected mammal species presence and abundance data for the three fossil assemblages and modern African communities. Dietary and substrate use functional traits were used in a correspondence analysis (CA) to reconstruct habitats. Abundances of bovids, equids, and giraffids were also compared with CA to examine their differing proportions at the fossil assemblages. The ranges and mean $d^{13}C$ signatures from mammalian teeth were compared among fossil assemblages as a measure of the dietary distribution of the herbivores. Finally, species diversity, diets, body sizes, and substrate use of the primates from each assemblage were examined. Results of the functional traits CA indicate that the three fossil localities had different habitats. Relative abundances give similar interpretations of habitats, with the eastern African sites being much more open than the woodland retrodicted for Makapansgat. The isotope analyses show that Ledi Geraru and Laetoli had more mixed feeders and grazers, in contrast to the preponderance of browsing taxa at Makapansgat. This suggests that the eastern African sites sampled more open grasslands, while habitats in southern Africa sampled more trees and shrubs. Finally, the primate communities were different among the assemblages, with Makapansgat indicating much more closed habitats. Overall, it appears that early *Homo* and *P. aethiopicus* existed in more open habitats with Ledi-Geraru exhibiting wetlands in contrast to Laetoli, and *Au. africanus* existed in a more wooded environment.

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Lost and Found: New Descriptions of Upper Paleolithic Humans From Ksar Akil, Lebanon

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New archival research at the Peabody Museum of Archaeology and Ethnology revealed photographs and radiographs of a previously undescribed individual from the Early Upper Paleolithic (EUP) levels of Ksar Akil (Lebanon), one of the few circum-Mediterranean archaeological sites with early fossils of *Homo sapiens*. The human fossil assemblage from Ksar Akil has a complex history. The skull and post-crania of the juvenile 'Egbert' (Ksar Akil 1) from the EUP levels are lost; the partial maxilla of 'Ethelruda' (Ksar Akil 2) from the Initial Upper Paleolithic levels has only recently been rediscovered, leaving an isolated deciduous molar (Ksar Akil 3) from Levantine Aurignacian strata. We provide a dental analysis of first-generation casts of Egbert and the first description of a "new" fourth individual found adjacent to Egbert in 1938 and only noted briefly in initial publications. Like Egbert, it is from level XVII or XVIII, conservatively dated from ~43–39 ka. The new individual consists of photographs and radiographs of dental/mandibular material only, found in the papers of J. Franklin Ewing, S.J., co-director of the Ksar Akil excavations and project physical anthropologist. The photographs and radiographs suggest a juvenile of 7–9 years, similar to Egbert. Compared to other fossil *H. sapiens* individuals, the teeth of Egbert and the new individual are remarkably modern. The upper and lower deciduous first molars are bicuspid; the upper deciduous second and permanent first molars possess quite reduced hypocones and square occlusal outlines. The lower first permanent molars are four-cusped, a rare trait even among recent *H. sapiens*. Its presence in two contemporaneous individuals at Ksar Akil suggest a possible locally distinctive population marker for groups in the Levant at this time, and thus one possible line of evidence useful for studies seeking to understand the demographic history of early *H. sapiens* in Europe and elsewhere.

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Multiproxy Analyses Indicate That New Middle Pliocene Hominin Fossils from East Turkana are Associated with Grassy Woodlands Amid Regional and Temporal Shifts in Aridity

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During the middle Pliocene (~3.8–3.2 Ma) both *Australopithecus afarensis* and *Kenyanthropus platyops* are known from the Turkana Basin, but between 3.60–3.44 Ma, hominins are only found on the west side of Lake Turkana. Here, we introduce the first known specimens from the Lokochot Member of the Koobi Fora Formation (3.58–3.44). To reconstruct the paleoecology of the associated hominin locality (ET03-166/168, Area 129), we utilize information from phytoliths, stable isotopes from plant wax biomarkers, pedogenic carbonates, fossil tooth enamel, sedimentology, and the relative abundances of associated mammalian fauna. Together this evidence provides a detailed view of the local paleoenvironment occupied by these Pliocene hominins. The combined evidence shows that these hominins were associated with a biodiverse community of primates and other mammals inhabiting woodlands mixed with grassy, humid environments in a fluvial floodplain setting. Between 3.58 and 3.44 Ma, increases in woody vegetation were, at times, associated with increases in arid adapted grasses. This evidence suggests that Pliocene plant communities dominated by woody vegetation periodically coincided with periods of prolonged aridity, similar to conditions today in the Turkana Basin where arid-adapted woody vegetation is a significant component of the ecosystem. Pedogenic carbonates are offset from other vegetation proxies indicating more woody vegetation, possibly due to differences in temporospatial scale and ecological biases in preservation that should be accounted for in future studies. Together, local-scale paleoecological evidence from East Turkana supports regional evidence that middle Pliocene eastern Africa may have experienced large-scale, climate-driven periods of aridity. These new hominin fossils, in combination with multiproxy paleoenvironmental indicators from a single locale through time, suggest that early hominin species occupied a wide range of ecosystems, including those in water-stressed environments. This information extends our understanding of hominin environments beyond the limits of simple wooded, grassy, or mosaic environmental descriptions.

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Origins of the Middle Stone Age: Potential Insight from the Olorgesailie Kenya Paleolake Basin

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The paleolake basin in Southern Kenya contains a stratified archaeological sequence which begins at ca. 1.1 Ma and continues into the Neolithic. Early Stone Age (ESA) materials span the time range of ca. 1.1 Ma to ca. 495 Ka and are overlain by multiple Middle Stone Age (MSA) sites, the earliest of which from "locality B" date from ca. 320 Ka to ca. 295 Ka years ago. Three *Science* articles published in 2018 describe, date, and set into environmental context these early MSA occurrences. They note that, in addition to their early age, they contain coloring materials of manganese oxide as well as obsidian from sources as distant as ca. 100km away. In this presentation we examine these early MSA materials in greater detail and compare them to ESA counterparts. We also focus on the site of BOK2 which includes the majority of the obsidian material. This site contains five stratified horizons, which provide a context for comparative analysis. In both the locality B MSA sites and across the individual horizons within BOK2, the frequency of obsidian varies significantly. Within the BOK2 assemblages and across MSA sites there is, however, a complementary relationship between obsidian and a second sharp edged material, Olorgesailie Basalt. When obsidian is rare, this basalt in effect takes its place. This relationship does not hold for the ESA sites in the sample. The classic definition of MSA is lithic defined and we hypothesize that the ESA – MSA transition results from a new focus on sharp cutting/scraping edges and the activities which they facilitate. This emphasis has a major impact on ranging behavior, which in turn affects multiple other aspects of human behavior.

Tinshemet Cave Project: Exploring a New Middle Paleolithic Site in Israel

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Tinshemet Cave, central Israel, is a newly excavated Middle Paleolithic (MP) site in the Levant bearing articulated human remains. The cave, which is composed of three chambers and a terrace, was not excavated before the current campaign was launched in 2016. To date, the remains of at least four human individuals were found at the site, including a fully articulated skeleton of an adult in the cemented MP deposits (breccia) on the terrace of the cave, as well as a partially articulated skeleton of a child found in the first chamber. The anthropological assemblage also contains two skulls of adults that are still under excavation. The deposits in both the terrace and first chamber include wood ash (at various states of recrystallization) and burned bones. The adult skeleton was found in an anthropogenic-rich layer. The lithic assemblage excavated so far is Levallois dominated, consisting of more than 6000 artifacts from the terrace and the first chamber. Faunal remains represent an array of local ungulate species, with aurochs (*Bos primigenius*), Mesopotamian fallow deer (*Dama mesopotamica*), equids (*Equus* sp.), and mountain gazelle (*Gazella gazella*) in near-even representation. Together with recently discovered late Middle Pleistocene *Homo* at Nesher Ramla, the anthropological and archaeological discoveries at Tinshemet Cave reignite debates on the timing and patterns of human dispersals and interactions in the MP. Our research objectives are to determine what *Homo* type inhabited Tinshemet Cave, establish a secure chronology for the site and the hominin remains, and characterize the cultural and technological behavior, as well as subsistence strategies of the cave's inhabitants. In this talk, we introduce the site, present the initial results of the excavations, and discuss them within the broader context of the MP archaeological record.