Recent Discoveries at Lusakert-1, a Late Middle Paleolithic Rockshelter in the Armenian Highlands

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Lusakert-1 is a stratified Late Middle Paleolithic sites in the Armenian Highlands (Gasparyan and Glauberman 2022), a mountainous region south of the Greater Caucasus situated between the Black and Caspian Seas. Excavations conducted by an international team between 2008 and 2012 document complex lithostratigraphic, chronometric, and tephra records spanning much of MIS 3 (Wilkinson et al. submitted), the latter record proving particularly challenging to interpret given the rich and poorly understood volcanic history of the region (Adler et al. submitted). Paleoenvironmental proxies such as stable isotopes of *n*-alkanes, wood charcoal, and microfauna as well as soil micromorphology, provide evidence for the mastery of pyrotechnology by the site's inhabitants and for climate and vegetation fluctuations, including at least one cool–warm–cool cycle, with an overall trend for increasingly open environments (Brittingham et al. 2019; Rey-Rodríguez et al. 2024; Wilkinson et al. submitted). The lithic and faunal assemblages document hominin technological, foraging and mobility behaviors centered on the use of numerous obsidian sources to produce flakes and blades from cores-on-flakes, the hunting of *Bos*, *Ovis*/*Capra*, and *Equus* sp., the transport of obsidian artifacts over >100 linear kilometers, and the exploitation of large territories comprising diverse elevations and biomes (Adler et al. 2012; Frahm et al. 2016). Finally, careful excavation, documentation, and taphonomic study identify a degree of spatial organization and a variety of archaeological features (e.g., hearths, a grass-lined pit, "camp furniture," and a refit bundle) and rarely preserved in Middle Paleolithic contexts, the meanings and uses of which are further contextualized through phytolith and ZooMS analyses. Here we provide a brief introduction to Lusakert-1 and then highlight several recent results that advance our understanding of Late Middle Paleolithic hominins in the region.

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Reconstructing Hunter-Gatherer Post-Marital Residence Patterns at Hora, Malawi, with Strontium Isotope Analysis of Pre- and Post-Weaning Molar Tooth Enamel

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Advances in understanding of female skeletal reproductive biology and physiology can contribute to more realistic reconstructions of post-marital residence (PMR) patterns with strontium isotopes of tooth enamel. Clinical research on lead isotopes shows that about half the lead in teeth formed prior to weaning is derived from the maternal skeleton. If similar amounts of strontium are transferred during lactation, then pre-weaning teeth (M1 and M2) may combine the strontium isotopic composition of the foodweb where the maternal skeleton was formed with that of the maternal diet in the region occupied during lactation. Third molars (M3) mineralize during adolescence. They preserve the isotopic composition the post-weaning diet in the adolescent to young adult home range. Assuming childbearing begins after females occupy their post-marital home range, then analysis of pre- and post-weaning enamel should reveal whether an individual's mother was born locally (matrilocal PMR) or moved to a new location before reproduction (patrilocal or neolocal PMR). Similar pre- and post-weaning isotope ratios would indicate matrilocal PMR; different ratios would reflect patrilocal or neolocal PMR. Analysis of bioavailable strontium isotope ratios in a ~50–55km diameter area centered on Mt. Hora, Malawi, provides a baseline isoscape for reconstructing the residential biographies of two individuals buried in the Holocene levels of Hora 1 Rockshelter. The northern half of this isoscape has high average foodweb $^{87}Sr/^{86}Sr$ and the southern half has lower average values. High $^{87}Sr/^{86}Sr$ of M1 and M2 of one individual and low ratios for the other indicate northern and southern maternal origins, respectively. M3s of both match the isoscape average within a 5km radius of Mt. Hora. These data suggest patrilocal or neolocal PMR for mothers of both individuals. These results show that analysis of pre- and post-weaning tooth enamel can be used to reconstruct this fundamental aspect of hominin mating systems.

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The Contribution of ESR Dating and its Implication for Human Evolution in Western Africa

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Compared to the other regions in Africa, the lack of paleoanthropological, archaeological, and paleoenvironmental data makes Western Africa still an enigmatic region for understanding human evolution. While recently excavated MSA and LSA sites have started to fill this gap in that region (Douze et al. 2021; Ndiaye et al. 2024; Niang et al. 2023; Schmid et al. 2021; Scerri et al. 2021), there is still a critical need for reliable chronometric dates to establish a secure timeline for the ESA and early MSA. The dating of Western African sites is difficult because the majority of dating methods (radiocarbon, U-series, Ar/Ar or K/Ar…) cannot be used due to the absence of suitable material (e.g., bones, charcoal, shells, calcite, volcanic minerals). However, quartz is systematically available at all the Western African Stone Age sites. Optically Stimulated Luminescence (OSL) has been almost exclusively used as the main alternative dating method to provide chronology for this region. However, OSL dating has also shown some clear limitations in the region, as it cannot be extended beyond ~150 ka and is simply not able to cover the entire MSA time range (Chevrier et al. 2018). In this context, the implementation of the Electron Spin Resonance (ESR) dating method in the MCSA-funded 'WATIME' project aims, using the ESR dating method, to contribute to the timeline of early MSA and MSA sites in Western Africa located in various current ecoregions (tropical forest, coast (Ben Arous et al. 2024), Sahelian savannah, ...). This key alternative method can provide a numerical age on the exact same material as OSL (i.e., quartz grains) and can potentially date back to between ~1–2 Ma (Duval et al. 2020). This paper presents an overview of recent chronological data from key Early MSA and MSA sites in Western Africa and the implications of these results for human evolution will be discussed broadly.

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Lower Paleolithic Tools of Potency: Handaxes Shaped Around Fossils and Other Extraordinary Features at Sakhnin Valley, Israel

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We report a group of Lower Paleolithic extraordinary handaxes found during a survey at newly discovered extensive Lower Paleolithic Acheulian localities in the Sakhnin valley, Lower Galilee, Israel. Sakhnin valley demonstrates rich surface concentrations of lithic artifacts, dominated by handaxes, cores, flakes, and debitage. The presence of handaxes alongside prepared cores hints towards a late Acheulian assignment of these collections, however, further field work will look into this aspect more thoroughly. The particular handaxes reported here are part of a wider collection of dozens of handaxes, bearing typical Levantine late Acheulian characteristics. What is exceptional about the handaxes presented here is the fact they were shaped around fossil imprints or other features embedded in the flint nodules selected for their production. While many thousands of handaxes were reported from Lower Paleolithic sites across the Old World, fossil-bearing handaxes are extremely rare and are the focus of special attention. The Sakhnin handaxes presented here provide an important addition to the very small collection of unique bifaces that might enable a glimpse into their makers' technological and aesthetic preferences, worldviews, and relationships with stone. We suggest that these particular handaxes acted as tools and symbols, conceived as tools of potency enhanced by the primeval fossil imprints and extraordinary features in the stone.

"So Full of Maggots": Insights on Diet Reconstruction from Stable Nitrogen Isotopes of Maggots

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Reconstructions of Eurasian Neanderthal and anatomically modern human diets based on stable nitrogen isotope ratios ($\delta^{15}N$) typically place these hominins at the top of the food web, together with, or above, hypercarnivores like cave lions and hyenas. However, for humans, sustained protein intakes at the levels of non-human hypercarnivores would lead to a debilitating, even lethal, condition historically known as "rabbit starvation." When interpreting $\delta^{15}N$ values of past hominins, we need to consider metabolic differences between hominins and non-human carnivores, the potential impact of food processing/storage techniques, and paleomenu items not readily observable archaeologically. We suggest that the high $\delta^{15}N$ values observed in Late Pleistocene hominins may be inflated by the year-round consumption of ^{15}N-enriched fly larvae (maggots) associated with dried, frozen, or cached animal foods. The ethnohistoric record contains many examples of Indigenous peoples routinely consuming putrefied animal foods which, regardless of season, contained large quantities of living and/or dead maggots. We compare $\delta^{15}N$ bulk analyses of fly larvae of three families (Diptera: Brachycera: Calliphoridae, Piophilidae, and Stratiomyidae) collected from muscle tissue undergoing putrefaction (decomposition). The putrefying tissue changed in $\delta^{15}N$ from initial values ($\Delta^{15}N$) ranging from -0.6 to 7.7‰. Changes in the $\delta^{15}N$ values of fly larvae feeding on these tissues were much greater over time, ranging from 5.4 to 43.2‰. Thus, year-round consumption of dried, frozen, or cached animal foods laced with maggots very likely contributed to high $\delta^{15}N$ values in Pleistocene hominins, placing them beyond one trophic level above the primary consumers in their ecosystems.

Forager Mobility During the Middle Stone Age at Blombos Cave, South Africa

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Archaeological research in South Africa's southern Cape continues to highlight the region's pivotal role in understanding the emergence of cultural modernity in early modern humans. However, key aspects of subsistence behavior, particularly lithic raw material procurement and related mobility patterns, remain underexplored. These behaviors are critical for the success of forager societies, shaping their adaptability and resilience across diverse environments. The dominance of silcrete tools in Middle Stone Age (100–85 ka BP) layers at Blombos Cave indicates a strong preference for this material in tool production. This study investigates the mobility and lithic procurement strategies of Blombos Cave inhabitants through petrographic and geochemical analyses. The results show consistencies to distant deposits, suggesting high mobility and targeted selection of raw material. This behavior reflects a sophisticated understanding of the landscape and provides valuable insights into the decision-making by inhabitants of the southern Cape.

Abiotic Effects on Skeletal and Dental Maturation Rates in Human Evolution

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In modern humans, dental development and skeletal growth rates are correlated for a given age. In contrast, some fossil hominins show a decoupling of dental development, brain size, and somatic growth rates. Evidence shows that climate and environment may be critical in inter and intra-species developmental plasticity. Yet, little is known about exactly how ecological conditions modulate the pace of hominin development. Macho (2017) has shown that in modern Cercopithecines and Hominoids, abiotic climatic variables, such as evapotranspiration, precipitation, and aridity index, positively correlate with life history traits such as interbirth interval and longevity. Other studies have pointed to the correlation of brain size with climatic variability and environmental heterogeneity (e.g., Potts 1996). Distinct life history changes, such as delayed maturation and secondary altriciality in modern humans, have been attributed to the rapid encephalization. For this study, we evaluated whether hominoid life history variability may be attributed to ecological abiotic factors and spatial-temporal variability. We correlated a suite of life history variables (e.g., the timing of first molar eruption relative to that of incisors, brain relative growth) with ecological and environmental conditions (e.g., environmental heterogeneity, temporal seasonality, abiotic parameters) across hominin specimens and modern population of *Pan* and *Homo sapiens* using non-parametric multivariate analyses (ANOSIM and non-metric multidimensional scaling). Preliminary results show a weak but significant association between challenging habitats with low nutritional predictability and delayed hominin dental development compared to species living in environments with high nutritional predictability. However, somatic maturation rates are less clearly correlated with environmental and climatic variables and may result from growth rates different from those of *H. sapiens*.

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Refining Analogies in Paleolithic Research: A Critical Examination of Contemporary Comparisons

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Applying analogies drawn from recent cultures and environments has long been a cornerstone in formulating predictions about Paleolithic subsistence strategies and human evolution. However, the validity and limitations of such analogies have been subjects of debate since the 1950s. Ascher (1961), drawing on the works of Clark, Willey, and Childe, proposed that analogies should be sought from "cultures which manipulate similar environments in similar ways." This criterion highlights the inherent challenges in applying direct analogies from modern hunter-gatherer behaviors to Paleolithic contexts, given the significant disparities in technology and environmental conditions. Current practices often involve either aggregating data from diverse modern environments or selecting a single, purportedly representative group. These approaches frequently fail to adequately account for the potential biases introduced by cultural and environmental differences between contemporary and prehistoric settings. This presentation will critically examine four case studies that exemplify the overly simplistic application of analogies in predicting Paleolithic human behavior and evolution. Building on this analysis, we will propose methodological improvements for developing more nuanced and contextually appropriate predictions. These strategies aim to: 1) account for technological disparities between modern and Paleolithic tools; 2) consider the impact of environmental changes over time; and, 3) develop more sophisticated models that integrate multiple lines of evidence. By refining our approach to analogical reasoning in paleoanthropology, we can enhance the accuracy of our interpretations and deepen our understanding of Paleolithic lifeways and human evolutionary processes.

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Paleoanthropological and Paleoecological Investigations in Albertine Rift, Western Uganda

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Investigations of the environmental context of early hominin evolution rely heavily on fossil and geologic evidence from a small number of research areas within the eastern branch of the African Rift. These areas, however, are unlikely to be representative of ecosystem change in other areas across the continent and likely underestimate the range of environmental conditions experienced by early hominins. The western branch of the rift has contributed comparatively little to human evolutionary debates, although prior work demonstrates the preservation of fossil mammals, including hominins and monkeys, as well as Pleistocene stone tools in Albertine rift sediments exposed in western Uganda and eastern DRC. Here we report on renewed paleontological, archaeological, geological, and geochemical investigations by the Nyabusosi Research Project within the Kisegi-Nyabusosi region of the Albertine Rift, western

Uganda. We provide preliminary results of paleontological and archaeological surveys in late Miocene- to Pleistocene-aged sediments. We find that many previously mapped and new localities in the area remain paleontologically productive. The diversity of recovered mammalian fossil remains include bovids, equids, hippopotamids, proboscideans, and suids, including dental and postcranial elements. In addition, we document abundant preservation of stone artifacts in the Nyabusosi Formation. Many of the lithics are consistent with Oldowan and Acheulean technology. We investigate the ecological history of the Albertine rift through stable isotope analysis of tooth enamel of late Miocene to Early Pleistocene mammalian herbivores. The diets of Upper Oluka Formation herbivores indicate the presence of closed canopy vegetation in the late Miocene, along with non-forest C_3 and C_4 biomass that remain abundant in the diets of Pliocene and Pleistocene herbivores. Ongoing paleontological, archaeological, and geochronological work will provide important context for interpreting evidence for hominin behavior and ecology in an important but poorly understood region in eastern Africa.

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Same Road, Different Path – the Lower to Middle Paleolithic Transition(s) in SW Asia as Seen from the New Excavations at Dalarik-1, Armenia

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Over the last 150 years the Paleolithic era has been divided into the Lower, Middle, and Upper Paleolithic. This chrono/cultural classification system is employed as the framework for reconstruction and understanding prehistoric behavior and cultural evolution. The transition between the Lower and Middle Paleolithic was suggested to represent a broadly contemporaneous global shift in material culture. This is thought to result from out-of-Africa dispersal(s) through the Levant conditioned by climatic and environmental constraints. However, the current results from the excavations of the Lower Paleolithic cave site of Dalarik-1, Armenia challenge the current scenarios about this transition. Dalarik-1 cave (930m asl) is located at the Mastaraheghegat River, at the northwest edge of the Ararat Depression. The cave is a small, corridor-type cavern. The ≥2m thick sequence encompasses seven main sedimentological units, at least five containing lithic and faunal assemblages. The rich lithic assemblage retrieved at the site is dominated by obsidian and a small percentage of dacite. Both raw materials are typified by off-site production of large non-Levalloisian blanks. Those blanks were shaped in high frequencies into bifaces that vary in size and shape as well as high frequency of side and transverse scrapers with stepped (Quina) retouch. The OSL chronology constrains site's entire stratigraphy and consequently human occupation to 250–160 ka (MIS 7-6). Based on the mapping of the earliest occurrences of the Middle Paleolithic, the suggested chronological range for the transition from Lower to Middle in SW Asia is placed at ~250,000 (MIS 8 to 7). The prevalence of Quina scrapers, ca. 1000km and 50,000 years later than their latest occurrence in the Levant complicates the out-of-Africa/out-of-the-Levant scenarios. Thus, the late occurrence and continuation of cultural traits at Dalarik-1 are at odds with the current transition and dispersion hypotheses.

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Exploring the Landscape and Hominin Behavior at FxJj20 Using Phytolith and Microscopic Charcoal Analysis

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Evidence of combustion associated with early Pleistocene archaeological sites at Koobi Fora in Northern Kenya takes the form of rubified sediments, burned bone fragments, and thermally altered lithics. The site complex FxJj20, in paleontological area 131, records the association of combustion in association with extensive archaeological evidence dating back to 1.5 Ma. Open air archaeological sites, like FxJj20, are highly susceptible to post-depositional damage. This requires the use of various methods to link evidence of combustion to hominin behavior. To provide a greater understanding of the placement of these behaviors in a broader context, here we describe a

landscape scale distribution of charcoal and phytoliths at a mesoscale distribution around FxJj20. We investigate the surrounding landscape to identify key landscape features that may have structured hominin behaviors in the region. Phytolith analysis allows us to understand the physiognomic structure of the ecosystem that hominins occupied across 0.8km^2 surrounding FxJj20. We used the presence of certain types of phytoliths (e.g., sedges) to identify areas of fresh water, as well as aspects of the water tables (e.g., palm phytoliths). This allowed the reconstruction of important landscape features like paleoriver channels. The recurring occupation of certain parts of the landscape may be driven by details of the paleogeography and appear to have influenced the landscape use as well as evidence of combustion across this 1.5 Ma landscape. Additionally, analysis of burnt phytoliths and microscopic charcoal suggests the presence of hominin behavior at various levels of intensity across this landscape.

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Rabbit Exploitation in the Middle Paleolithic: Insights from Experimental Archaeology Applied to the Level JJ Faunal Assemblage from Lapa do Picareiro, Portugal

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The archaeological record from southwestern Europe, particularly the Iberian Peninsula and southern France, demonstrates the consistent inclusion of small prey, especially Leporidae, in the subsistence behaviors of both Neanderthal and anatomically modern human groups during the Middle and Upper Paleolithic. Despite their prevalence in relevant faunal assemblages, the methods used to hunt and process these animals, as well as the techniques for preserving their meat, remain underexplored. This study aims to address these gaps through an experimental program investigating three cooking and preservation methods—roasting, smoking, and drying. Eight rabbits were prepared using each method, with subsequent taphonomic analysis conducted on the resulting bone assemblages. The observed modifications were then compared with those identified in an archeological contexts from the Paleolithic Iberian Peninsula, particularly, rabbit remains from the Middle Paleolithic Level JJ of Lapa do Picareiro, a cave site situated in Portuguese Estremadura. By providing a comprehensive dataset of experimentally derived bone modifications, this research offers a reference for interpreting small prey assemblages and elucidates the economic behaviors of Middle Paleolithic human populations. These findings enhance our understanding of human subsistence strategies and contribute to broader discussions on mobility, resource management, and cultural practices in prehistoric Europe.

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Late Pleistocene Guangxi: A Paleoecological Analysis Based on Primate Genus-Level Data

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The biochronology, biogeography, and paleoecology of Pleistocene southern Chinese primates are still relatively unknown. We present data on the primate assemblage from Yahuai (~120 k cal BP to ~40 k cal BP), Guangxi Zhuang Autonomous Region, China. This assemblage is unique in that extensive wet sieving was conducted, which resulted in the collection of a significant micro and small mammal assemblage. Primate dental and skeletal remains were recovered from 20 strata from Area A, ranging from 124.2±16 ka to 39,030 cal BP. However, many strata included very few specimens, with most specimens retrieved from strata 9 and 36 probably attributed to excavation volume rather than a genuine ecological shift. Diversity was compared to primate species diversity in nine Pleistocene sites and modern-day Guangxi. ArcGIS Online created species distribution models representing all extant primates in southern China, which were used to extract the species present across five randomly plotted localities. The assemblage comprised 492 specimens, of which 69 dental fragments could be identified to the genus level. Yahuai species richness (S=5) was consistent with other Pleistocene sites (S=4 to 7). In contrast, all modern localities had lower species richness (S=1 to 2), pointing to the extirpation of many species in the Holocene. To facilitate comparison across the region during the Pleistocene, we conducted a non-metrical multidimensional scaling ordination using a Gower similarity index (Past v4.6) on presence-absence genera-level data. Results suggest that Yahuai significantly differs from other Pleistocene sites in the region. This is attributed to the presence of *Hylobates* and *Presbytis* in Yahuai. This may reflect sampling biases

across sites not sieved through a fine mesh, differences in taphonomy, or temporal-spatial shifts in species distribution. Nonetheless, paleoecology points to climate stability between the late Pleistocene and today, suggesting that such changes, if they occurred, may have been very subtle.

What Does 'Controlled' Bipolar Lithic Reduction Look Like? An Exploratory Experiment

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This study introduces a novel experimental approach to bipolar reduction using standardized glass balls as proxies for lithic materials. Traditionally, bipolar reduction is considered a less controlled knapping strategy, primarily used under resource-limited conditions or by "unskilled" knappers. Our experimental design aimed to revisit this assumption by implementing a controlled setting that isolates variables affecting bipolar core and flake production. The experiments were conducted at the Kent State Experimental Archaeology Laboratory, employing an Instron Materials Tester and a traditional human-knapper setup to compare mechanical and manual bipolar reduction processes. Glass balls, selected for their homogeneity and comparability to chert and flint, were subjected to reduction using three distinct methods—static compression testing, human knapping on a stone anvil, and a mechanical device termed "the crazy crusher." Preliminary results highlight the mechanical tester's ability to produce recognizable bipolar products, similar in form to those created by traditional human knapping. Conversely, the mechanical crusher was ineffective, only pulverizing the glass without generating easily recognizable cores and flakes. This outcome underscores the critical role of the flake escape mechanism in controlled bipolar reduction, suggesting that spatial dynamics within the bipolar reduction setup significantly influence the resulting core and flake quality and production efficiency. These findings not only challenge traditional perceptions of bipolar knapping as an uncontrolled, less efficient reduction strategy but also enhance our understanding of the conditions under which this technique might have been preferred in prehistoric contexts. The controlled experimental setup provides a scalable model for further investigation into the variables influencing bipolar reduction strategies, thereby contributing to a deeper understanding of this ubiquitous lithic reduction strategy.

Ecology, Phylogeny, and Tool Use: Rethinking Manual Proportions in Human Evolution

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Understanding whether specific anatomical features of the hand are linked to tool use has been a key aspect of studying the evolution of technology in humans. Most traits associated with an ability to use tools (e.g., thumb-to-digits ratio, broad distal phalangeal tuberosity) are linked to differences in manual proportions across taxa. However, manual proportions can be driven by locomotion and/or phylogeny, and tool use should also be understood under an ecological lens. Previous research has focused on comparing manual proportions between fossil hominins and extant primate species with a clear bias toward the apes (e.g., Alba et al. 2003; Rolian and Gordon 2013). To fill this gap, some studies have incorporated other primate taxa in their comparative analyses (e.g., Feix et al. 2015; Liu et al. 2016), but never simply considered differences across manual proportions. Thus, I aimed to compare the manual proportions of tool-using and non-tool-using monkeys to test whether tool use is a matter of hand morphology or ecological necessity and/or opportunity in these taxa. I hypothesized that manual proportions (length and breadth ratios) of tool-using monkeys would be different from their non-tool-using counterparts, thus supporting the different morphology perspective. My results reveal that ecological necessity and/or opportunity seem to be the best explanation for tool use and that phylogeny and locomotion are the main drivers of manual proportions in monkeys. Tool-using capuchin monkeys (*Sapajus* spp. and *Cebus* spp.) and macaques (*Macaca* spp.) have significantly different manual proportions, thus highlighting that taxa with different hand morphologies can achieve the same result—the notion of equifinality. Overall, this study emphasizes that manual proportions are not the best proxy when it comes to reconstructing the origins of technology and its connection with hand anatomy in human evolution.

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Revised Chronology of a Late Upper Paleolithic Mammoth Bone Structure at Mezhyrich, Ukraine

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This study presents new radiocarbon (^{14}C) results from Mezhyrich (Cherkasy Oblast, Ukraine), providing a revised chronological framework for Mammoth Bone Structure 4, a significant Late Upper Paleolithic site in East-Central Europe. Unlike previous chronological models based on dates from mammoth bone remains, we directly dated meso-mammal remains recovered from well-provenienced cultural layers. This approach offers a more accurate and constrained estimate of the site's occupation. Our results indicate that the cultural layers associated with Mammoth Bone Structure 4 and its immediate spatial context date suggest a far more compressed occupation span than previously thought. This refined timeline is notably shorter than earlier estimates, prompting a reassessment of the site's function and significance. These findings shed light on the diverse settlement patterns and adaptive strategies employed by Late Upper Paleolithic communities in Eastern Europe. By situating the use of Mammoth Bone Structure 4 within a shorter and more defined period, this research enhances our understanding of human responses to glacial environments. It underscores the importance of integrating well-contextualized radiocarbon dating with archaeological interpretation to resolve longstanding debates about site use and cultural behavior.

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The Upper Paleolithic and Epipaleolithic Fauna from Sefunim Cave (Mt. Carmel, Israel): New Insights from the Ungulate Assemblage

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With deposits spanning from the Middle Paleolithic through the Holocene, Sefunim provides an important opportunity to explore variation in animal use across a period of significant environmental, biocultural, and technological change. Here, we present results from ongoing analysis of the fauna from Layer V (Levantine Aurignacian, ~30–40 kcal BP), Layer IV (Late Upper Paleolithic, ~28–26 ka), and Layer III (Early Epipaleolithic, ~24–21 ka), focusing on the ungulate remains identifiable to the species-level (NISP: 4696). Gazelle and fallow deer are the most common taxa in each layer, with gazelle increasing in frequency from 53.4% in Layer V to 61.8% in Layer III. Fallow deer are fairly consistent throughout, ranging from 27.3%–30.7% of the assemblage. The frequency of gazelle at Sefunim is notably lower than that in comparable assemblages from the southern Levant, where gazelle typically account for >70% of ungulate fauna in the Aurignacian and >80% in the Epipaleolithic. The only UP assemblage with a comparable frequency of gazelle derives from Kebara, where they account for ~49% of the ungulate assemblage (Speth 2019); however, Yeshurun (2020) proposed that this could reflect greater hyena activity, given that hyena preferentially target fallow deer. At Sefunim, geoarchaeological data and relative find density indicate high intensity human occupation in Layer V and Layer III; however, Layer IV appears to capture shorter episodes of human activity interspersed with hyena occupation. Notably, Layer IV is also the only horizon in which the frequency of carnivore damage exceeds that of cut or percussion marks (for gazelle and fallow deer). As such, while the comparably low representation of gazelle in Layer IV may relate in part to hyena activity, the same cannot be argued for Layers V and III. In considering the implications of these results, we also address broader data on gazelle exploitation, including age profiles.

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Low-Cost Niche Construction can Create Conditions for Subdivided Populations Without Socially Imposed Boundaries

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Modern human uniqueness is often defined by a reliance on social learning and hierarchical cooperation networks that result in cumulative cultural evolution. There is archaeological evidence that such social organization emerged through innovations that facilitated exploitation of resources that naturally occur in dense and predictable patches. However, another way humans can reconfigure patch density and distribution is through the transformation of the environment itself via niche construction. Large-scale environmental modification through human-initiated disturbances has been documented for early modern humans in Africa by at least 85 thousand years ago, allowing an extended period of niche development. Here, we use an agent-based model to investigate how low-cost niche construction behaviors, which can be readily applied without intensifying to the point of food production, can transform resource distributions over time. We then examine the resulting impact of this on human mobility and social organization. In all scenarios where the cost of disturbance is low, we see positive selection for disturbance behaviors that lead to foragers creating a locally heterogeneous resource landscape. This results in increased carrying capacity, higher population densities, reduced mobility, and smaller social networks. We demonstrate that foragers using even very low-cost niche constructing behaviors can produce novel resource distributions on legacy landscapes that create conditions for incipient regionalization without intensive exploitation of specific resources or socially imposed boundaries.

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The Effects of Carnivore Diversity on Scavenging Opportunities and Hominin Range Expansion during Out of Africa I

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Numerous extrinsic hypotheses explaining Out of Africa I, like faunal turnover and hominins following fauna, have been rejected based on paleoecological models. Others have explored the importance of the hominin intrusion into the carnivore guild. Here, I build on this hypothesis by proposing a complementary hypothesis, carnivore guild flexibility hypothesis (CGFH). In eastern Africa, carnivore richness peaked around 3 Ma and declined gradually until shortly after 2 Ma. This timeline coincides with the development of early lithic technologies and initial evidence of the butchery of large mammals, thus implying that increased hominin carnivory impacted endemic carnivore diversity through the transition from passive to confrontational scavenging. The CGFH posits that the relatively stable carnivore diversity and richness in Eurasia permitted hominin range expansion into Eurasian habitats after 2 Ma due to scavenging opportunities along continuously overlapping carnivore ranges. This study tests the CGFH by examining carnivore diversity at African and Eurasian sites covering intervals before, during, and after initial Out of Africa I dispersals. This study builds on previous hypotheses about the role of carnivore guilds in hominin dispersals while tying in theoretical models on modes of early hominin carnivory and actualistic research on scavenging opportunities resulting from carnivore guild composition.

Variability Selection in Human Evolution: Versatilist Allele Success in Discrete and Temporally Unpredictable Environments

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Potts' (1996) variability selection model is premised on the idea that "versatilist" alleles conferred behavioral plasticity within some hominin lineages, ultimately resulting in our species. Grove (2011) mathematically demonstrates the viability of versatilist alleles in the context of human evolution. We follow Grove and Potts by modeling evolution from a simple one locus, three allele system (two specialists and one versatilist). Our model operates under the premise that organisms experience environments as discrete ("chunky") rather than continuous functions (e.g., from an organismal perspective, forested and savannah habitats are qualitatively distinct, while a mixed woodland habitat represents a heterogeneous environment). We simulate the impact of population size and the effect of environmental stability on the success of the versatilist allele to address three questions: 1) is the effect of population size on versatilist success the same in continuous versus "chunky" environments?; 2) do versatilist alleles succeed as well under unpredictable environmental shifts?; and, 3) does higher environmental instability favor versatilist alleles? We test four population sizes (200, 300, 500, and 1000) and randomized sequences of three environmental conditions (xeric, mixed, and mesic) over four stability durations (every 10, 20, 50, and 100 generations). Each parameter combination was simulated 100 times for 3000 generations. Our results support Grove's assertion that versatilist alleles could persist and become fixed disproportionately to competing alleles in small populations. We find convincing evidence that increasing the frequency of habitat shifts confers additional advantages to the versatilist allele. When population size increases, greater environmental instability improves the success of the versatilist allele. However, regardless of population size, more infrequent ecological shifts reduce the success of the versatilist allele relative to xeric and mesic alleles. Despite small fitness

differences among genotypes, allele fixation before 3000 generations was observed in all simulations.

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Variation in White-Tailed and Mule Deer Dental Metrics is Associated with Precipitation Gradients in the Americas

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Reconstructing past environments is crucial to understanding the selective pressures that drive hominin evolution. Of the varied approaches to exploring this relationship, macroscopic tooth wear analyses of fossil ungulates (e.g., mesowear) are widely used to reconstruct hominin environments. However, more work is needed to understand if and how tooth wear and adaptations to tooth wear differ inter- and intra-specifically between geographically widespread, large-bodied mammalian populations. This project characterizes molar hypsodonty indices and mesowear scores of white-tailed (*Odocoileus virginianus)* and mule deer (*Odocoileus hemionus*) across North and Central America, investigating if and how molar wear and morphology vary over the deer's large and ecologically variable geographic distribution. While mesowear scores generally do not strongly track environmental signals within and between *Odocoileus* species, hypsodonty indices reveal a strong correlation between crown height and aridity, likely representing an adaptive response to abrasive diets in areas with low precipitation. Future directions should include studies on how tooth wear is impacted by environment type and aridity within specific regions of white-tailed and mule deer sympatry to determine what phylogenetic constraints may influence adaptations to tooth wear.

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Renewed Archaeological Explorations in the Nyabusosi Formation of the Albertine Rift, Western Uganda

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The Nyabusosi Research Project is renewing paleoanthropological research in the Nyabusosi Formation in western Uganda, seeking to understand the forces driving human evolution by investigating the diversity of adaptive challenges faced by hominins and their technological responses. Here, we report on the results of archaeological surveys and test excavations at two newly identified localities. Preliminary lithic data from these sites are consistent with patterns found elsewhere in contemporary sites in eastern Africa and at the localities where previous archaeological work took place in the Nyabusosi formation (Pickford et al. 1989; Texier 1995, 1997), including a predominant pattern of bifacial flake production that includes evidence for early prepared core technology (Mesfin and Texier 2022). Our work stands out with the collection of archaeological material from new localities in the Makondo (2–1.8 Ma), Behanga (1.8–1.5 Ma), and Kagusa (1.5 Ma) members of the Nyabusosi formation (Roller et al. 2010), including the presence of biface technology. Surveys identified two areas with significant concentrations of artifacts and fossils and were the focus of test excavations—Bugando 1 (BUG-1) (Makondo member) and Bugando 2 (BUG-2) (Kagusa member). The lithic technology at these sites showed clear differences in the proportion of raw material types and in other technological elements (e.g., the presence of bifaces at BUG-1). The BUG-1 excavation did not yield *in situ* material, but more surface artifacts found at the site suggests that an *in situ* archaeological lens exists. In contrast, the test excavation at BUG-2 yielded an *in situ* horizon with a dense concentration of artifacts (n=197 lithics). The two new archaeological sites make a significant contribution to what little is known about Early Pleistocene lithic technology in the Albertine Rift. Future archaeological fieldwork and technological analyses, combined with paleoenvironmental and geochronological work, will build a better understanding of changing environments and hominin behavioral adaptations in an understudied region in human origins research.

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Experimental Tests of Different Hafting Configurations for Backed Segments as Arrowheads

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The Howiesons Poort technocomplex of southern Africa (65–60 ka) is characterized by the production of backed semi-circular lithics. These have been proposed to function as arrowheads in varying hafting configurations (Lombard and Pargeter 2008). We replicated Howiesons Poort segments and hafted them onto arrows in two different hafting configurations—transversal and diagonal. We shot the arrows into gelatine blocks to compare the size of wounds produced and the penetrative power of the configurations. Our results show that arrows tipped with transversally hafted segments consistently penetrate better than arrows with diagonally hafted segments although no clear difference in wound size is apparent between the different configurations.

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An Origin of Hominin Stone Knapping via the Emulation of Mother Nature

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The use of stone hammers to produce sharp stone flakes—knapping—is thought to represent a significant stage in hominin technological evolution because it facilitated the exploitation of novel resources, including meat obtained from medium-to-large-sized vertebrates. The invention of knapping may have occurred via an additive (i.e., cumulative) process that combined several innovative stages. Here, we propose that one of these stages was the hominin use of "naturaliths," which we define as naturally produced sharp stone fragments that could be used as cutting tools. Based on a review of the literature and our own research, we first suggest that the "typical" view, namely that sharp-edged stones are seldom produced by non-primate processes, is likely incorrect. Instead, naturaliths can be, and are being, endlessly produced in a wide range of settings and thus may occur on the landscape in far greater numbers than archaeologists currently understand or acknowledge. We then explore the potential role this "naturalith prevalence" may have played in the origin of hominin stone knapping. Our hypothesis suggests that the origin of knapping was not a "Eureka!" moment whereby hominins first made a sharp flake by intention or by accident and then sought something to cut, but instead was an emulative process by hominins aiming to reproduce the sharp tools furnished by mother nature and already in demand. We conclude with a discussion of several corollaries our proposal prompts, and several avenues of future research that can support or question our proposal.

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An Eastern Mirage? A Quantitative Evaluation of the Technological Affinities Between Early Ahmarian and Protoaurignacian

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The biocultural processes that led to the transition from the Middle to the Upper Paleolithic remain among the most debated topics in prehistoric archaeology. A key aspect of this debate concerns the dispersal of *Homo sapiens* foraging groups across the Mediterranean Basin. Within this framework, similarities between sub-contemporaneous stone tool industries have often been interpreted as evidence of underlying demographic processes. One long-standing assumption is the techno-typological relationship between the Levantine early Ahmarian and the European Protoaurignacian, with some scholars suggesting that these terms refer to the same cultural phenomenon (*Zilhão et al.* 2024). While this cultural link has become widely accepted in the literature as evidence for one of the East-West demic spread of *Homo sapiens*, no studies to date have quantitatively assessed the similarities and differences between these two lithic traditions. In this paper, we present the results of a quantitative comparison between the early Ahmarian (layers XX–XVI) and Upper Paleolithic (layers XIII–XIB) lithic assemblages from Ksar 'Akil, and some of the earliest Protoaurignacian assemblages from the Italian Peninsula (Grotta di Fumane, Riparo Bombrini, and Grotta di Castelcivita). This analysis, framed within the theoretical context of cultural transmission processes, tests the degree of dissimilarity across several technological domains of the core reduction sequence (Cascalheira 2019; Tostevin 2007). Our findings demonstrate that the Protoaurignacian differs significantly from both the early Ahmarian and the Upper Paleolithic layers XIII–XIB at Ksar 'Akil. These results challenge the assumption that lithic evidence supports a demic spread of foraging groups bearing the same technological traditions. Instead, they underscore the need for more nuanced hypotheses regarding the development of the Upper Paleolithic, both in Europe and beyond.

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How Well Does Herbivore Relative Abundance Reflect Vegetation Types on the Landscape? An Approach Using Agent-Based Modeling

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The relative abundance of fossil herbivores with varied dietary functional types (DFTs: grazers, browsers, mixed feeders) is often interpreted as reflecting the proportion of associated vegetation types (grassland vs. woodland) on ancient and modern landscapes. However, fossil herbivore relative abundance may also be impacted by variables such as uneven preservation of fossils across landscapes, how vegetation growth is influenced by proximity to water, and differences in biomass availability in woody versus grassy habitats. Here, we develop an agent-based model (ABM) to explore how three variables impact proportions of DFTs in the mammalian fossil record: 1) the spatial extent of diverse habitat types on the landscape, 2) available biomass provided by each vegetation type, and 3) the fossilization potential of each habitat type, parameterized based on hypothetical estimated sedimentation rates for each habitat. We ran 2275 simulations in which these variables changed systematically on a modeled (41 by 41 pixel) landscape containing a river channel, with woodland proximal to the channel, and a distal dry grassland. In these simulations herbivores move around the landscape, die at random, and are fossilized based on the estimated fossilization potential of the habitat they died in. The spatial extent of the habitat on the landscape, biomass availability, and fossilization potential were all significant predictors of the proportion of associated DFTs in the modeled fossil record (Generalized Linear Model with binomial response variable, $p<0.001$). Modeled results confirm —as often assumed—the proportion of DFTs in the fossil record is influenced by the spatial extent of specific habitats on the landscape. These findings highlight the potential to estimate the balance of grassland versus woodland vegetation using DFT proportions, but they underscore the need to account for the dynamic influences of fossilization potential and the relative availability of biomass when reconstructing these distinct ecosystems.

One Color to Rule Them All: Heated and Natural Red Ochres 100,000 Years Ago at Tinshemet Cave, Israel

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The new Levantine Middle Paleolithic (MP) site of Tinshemet Cave (Israel) constitutes the fifth MP site in the region that contains ochres. The ongoing excavations have unearthed several human remains and provided more than 7,000 ochre fragments clearly dominated by red hues (≈65%) The preferential extraction of red hematite ochres as well as the obtention of red color by intentionally heating chunks of originally yellow goethite has been previously discussed as integrating part of symbolic systems during the MP and the Middle Stone Age. Here we present the methods employed for deciphering heating of ochre in Tinshemet Cave as well as the results for the assessment of the occurrence of intentional ochre heating at the site. We applied a novel methodology that combines XRD plus FTIR to differentiate between red ochres resulting from heating and those of geogenic origin. This methodology was applied to 35 archaeological samples. The uneven widening of unstable hematite peaks is calculated as ratios relative to its stable peaks using XRD. Additionally, remains of goethite bands and thermal changes in clay peaks are traced under FTIR. The spatial distribution of heated ochres (over 50%) and red ochres of geogenic origin suggests that the transformation of originally yellow materials by heating was controlled by the occupants of Tinshemet Cave, demonstrating a clear preference for red hues. We consider the preference for the selection, production, and use of ochres of red hues to be evidence of chromatic symbolism by the inhabitants of Tinshemet Cave. Considering that the ochre assemblage is found in context with numerous human remains, we suggest the existence of complex social practices and symbolism at Tinshemet Cave.

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Pleistocene Behavioral Landscapes of Northern Armenia Project

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The objective of the Pleistocene Behavioral Landscapes project is to expand our understanding of hominin occupation and behavior in the Armenian Highlands during the Upper Pleistocene via geological and archaeological research in the Debed Gorge of northern Armenia. This project will refine the chronology of Middle Paleolithic sites in the Debed Gorge, correlate the sedimentary sequences at these sites, reconstruct local paleoenvironments—especially during the understudied Marine Isotope Stage (MIS) 5—and clarify Upper Pleistocene techno-typological sequences in the region. Here we report the background and preliminary results from the first year of fieldwork on this project, focusing on the open-air sites of Ptghavan-4 (PTV-4) and Bagratashen-1 (BGN-1). PTV-4 provides rare data on Middle Paleolithic hominin behaviors in this region during the early Upper Pleistocene. The site contains a dense concentration of Middle Paleolithic artifacts within a pedogenically modified aeolian deposit, currently dated to MIS 5e/d. PTV-4 is the only high-density archaeological site from MIS-5 with the potential for large horizontal spatial analyses in the region. BGN-1 is 5km to the west of PTV-4 within the Debed Gorge and contains Middle Paleolithic material within an aeolian or floodplain deposit. Published dates from this site place it in late MIS 3 (Egeland 2016), but work on landscape formation and technical issues with the dating methods suggest these are underestimates. Initial comparisons between these sites show differences in land use and technological behaviors, which will be clarified through continued technological analysis. The ongoing work of this project will enrich our understanding of the Middle Paleolithic in the Armenian Highlands and southern Caucasus.

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Are Human Tooth Marks Truly Unique?: A 3-D Comparison of Human and Carnivore Tooth Induced Bone Surface Modifications

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The archaeological record may reveal a history of ancient human cannibalism, but confirming it remains challenging. While cut and/or percussion marks on human remains may be indicative of human cannibalism, such evidence is not definitive, as other activities can produce similar markings. In contrast, human tooth marks on ancient human bones offer much more direct evidence of human cannibalism. However, due to similarities between human and carnivore tooth marks, distinguishing between the two with traditional analytical methods remains challenging. Therefore, the goal of this research was to determine whether human tooth marks are quantitatively distinct from carnivore tooth marks and other bone surface modifications (BSM), including cut, percussion, and trample marks. An experiment was conducted in which human participants consumed the meat of two cooked pig bones using only their teeth, producing 140 tooth marks. These marks were then 3-D scanned using a Sensofar 3-D optical profilometer and subsequently measured using Digital Surf's MountainsMap® software. The 3-D variables collected for each mark included surface area, volume, depth, length, and width, and the 2-D variables included area, roughness, opening angle, and radius. The human tooth marks were then statistically compared to 898 experimental BSMs of known origin, including 275 carnivore tooth marks. Analyses revealed that human tooth marks are distinguishable from those produced by carnivores, as 89.3% of the 140 human tooth marks were correctly classified as human-made when compared to the 275 carnivore tooth marks. Additionally, when compared to all experimentally produced BSMs (n=898), human tooth marks were correctly classified 82.1% of the time. Overall, this study demonstrates that human tooth marks are quantitatively distinct from carnivore tooth marks and other BSMs. These findings allow for more accurate identifications of ancient human cannibalism in the fossil record, and therefore, more accurate interpretations of ancient human diets.

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The Persistence of the Ebro Frontier Model and the Middle to Upper Paleolithic Transition in Iberia

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The Ebro Frontier model was framed around the idea of late persistence of Neanderthal and/or Middle Paleolithic sites and that a biogeographic boundary separated modern humans in northern Iberia from Neanderthals south of the Ebro River. After 15 years of redating purportedly late Neanderthal sites, it is now obvious that there were few if any Neanderthals left after 42 ka calBP. What was once a pattern of late Neanderthal sites spread across southern Iberia suggesting a robust population at sufficient density to maintain reproductive viability has transformed into a pattern of maybe one or two possibly late Neanderthal sites in isolated pockets along the margin of the southern and western fringes. The model is left with the hypothesis of a biogeographic boundary at the Ebro River preventing modern humans from entering an almost entirely vacant landscape. Given the modern human pattern of dispersal, it seems highly unlikely that any unpopulated environment was a barrier to colonization. Modern humans settled a multitude of environments between 65–45 ka. Paleoclimate and paleoenvironmental reconstructions indicate that Iberia would have been habitable even during extreme events such as Heinrich stadials. Nothing about the plant and animal communities south of the Ebro River made them somehow less attractive or even alien to modern humans who had reached Catalunya and Cantabria. The main impediment to resolving the problem is a relatively high visibility of archaeological sites dated 42–37 ka in northern Spain and a low visibility of sites in southern and western Iberia dated to the same interval, possibly due to environmental forcing mechanisms. The Ebro Frontier hypothesis should be set aside unless or until substantive evidence emerges of widespread Neanderthal presence in Iberia south of the Ebro. At present, the best and most securely dated evidence points to modern humans in the region.

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Bigger is Not Better: Unexpected Relationship Between Prey Body Size and Macronutrient Composition in East African Mammals

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It is widespread in reconstructions of hominin diets to assume a positive relationship between proportional body fat and body size in prey species which has implications for hominin dietary evolution. This assumption is, however, based on estimates derived from non-African species (typically European and North American mammals), and/or domesticated mammals, as proxies for wild African mammals. Here, we test the validity of this assumption for African hominin diets by compiling macro-nutritional data on proportions of lipids, carbs, and protein in African mammals and examined their relationship to body size. Available data demonstrated that African mammals typically defined as large game (>5kg), are relatively lean. Small game (<5kg) African mammals are more variable in macronutrient composition but are generally fattier relative to body size than large game. The only exceptions are mega-herbivores (>1000kg), such as hippopotamus and elephant. Our analysis suggests that the use of non-African mammals as a proxy for nutritional composition of African hominin diets is unreliable, which has implications for how the behavioral ecology of African hominin groups has been reconstructed.

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Variation in Manual Phalangeal Curvature Across Sex and Digit in Western Gorillas (*Gorilla gorilla*) Versus Eastern Gorillas (*Gorilla beringei*)

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Gorilla gorilla (western gorilla) and *G. beringei* (eastern gorilla) are two species of the same genus that exhibit variable locomotor strategies based on habitat and body size. *G. gorilla* inhabits denser, continuously forested habitats and are more arboreal and frugivorous than *G. beringei*, which inhabits higher altitude environments with a more dwarfed vegetation. Prior studies have documented morphological differences in the skeletons of these species that appear to track these differences in habitat use. Phalangeal curvature has previously been associated with frequency of climbing and suspension in primates. This study aimed to evaluate the relationship between manual phalangeal curvature and arboreality between *G. gorilla* and *G. beringei* and to examine sources of variation including sex and ray number. We hypothesized that *G. gorilla* would have higher phalangeal curvature than *G. beringei* due to more frequent arboreal behaviors. Additionally, we predicted females of both species would have greater curvatures due to lower body masses allowing easier access to trees. Shaft curvature was measured via the included angle method calculated from landmarks taken on 3D polygon models of manual proximal phalanges of rays 2–5. Results indicate high variability across the sample and although mean phalangeal curvature was highest in *G. gorilla* in both sexes, these differences were ray dependent such that there was no overall significant difference between species. Ray number was a significant source of variation with the fourth digit being consistently the most curved phalanx and this is more pronounced among females. Contrary to our hypothesis regarding sex differences, males in both species exhibit a higher mean phalangeal curvature than do females though this sex effect was not statistically significant. Overall, these results offer little evidence that manual phalangeal curvature tracks differences in arboreal behavior among species of *Gorilla*.

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Who Made the Late Stage 3 Levallois Industry in Eastern Europe?

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We report new radiocarbon dates obtained on bone with the XAD method (Stafford et al. 1991) for several East European Levallois assemblages traditionally classified as Middle Paleolithic. The sites are found in the Dniester Valley and Crimea. The new dates, which suggest an age of less than 50,000 years for these assemblages, are supported by paleomagnetic stratigraphy in the case of the Dniester Valley. Relatively young radiocarbon dates have been reported on other Levallois assemblages from Crimea and other parts of Eastern Europe (classified as Middle Paleolithic) prompting the suggestion that they represent a late survival of Neanderthals in Eastern Europe. This suggestion has been received with skepticism and the observation that at least some of the relatively late radiocarbon dates are problematic (e.g., Pigott et al. 2024). We propose an alternative explanation—that the late Stage 3 Levallois blade and flake assemblages of Eastern Europe were made by modern humans and represent a regional variant of the Initial Upper Paleolithic (IUP). The IUP now is reliably attributed to modern humans (Hublin et al. 2020), while none of the Levallois assemblages is associated with diagnostic human skeletal remains and all Neandertal remains from Eastern Europe are found with a non-Levallois Middle Paleolithic industry (*Micoquian*). Although formally assigned to the Middle Paleolithic, the Levallois blade and flake assemblages exhibit a technology

similar to that of the IUP, which—with the exception of Kulychivka in western Ukraine (Koropetskyi et al. 2021)—is absent in Eastern Europe.

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Computer Vision-Aided Identification of Worked Materials from Lithic Use Wear Polish on Chert

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Lithic microwear is one of the few methods for reconstructing the function of Paleolithic stone tools. While inferring worked materials from microscopic polishes is considered important, traditional visual inference from the microscope is difficult and subjective, so confidence in the technique among Pleistocene archaeologists is low. To remedy this, we turn to artificial intelligence-aided classification. Recently, our team published the first large-scale benchmarking of different vision foundation models (ResNet, ViT, DINOv2, ConvNeXt, and GPT4v) for use-wear polish classification (Zhang et al. 2024). Trained on confocal scans of chert worn in both controlled (robotic) and human experiments, DINOv2 performed best, with a success rate of 67% on test data. This is significantly better than human experts, as documented in published blind tests (ca. 50%). Moreover, our LUWA algorithm is able to mimic human expert performance on new datasets, by learning about the new data from only a few examples, a task where it also outperforms human experts. Here we present the results of the refined LUWA algorithm applied to a dataset of images and heightmaps extracted from confocal scans of polish on chert artifacts taken with a 3D optical profiler (Sensofar S-NeoX). A human expert (RI) segmented the scans to train the model to recognize polish. In a second experiment, experimental tools made on different chert raw materials were used by one co-author (DM) and the data collected using the same optical profiler were used to test the model. The algorithm classified antler well but did very poorly on wood, probably because of low data diversity in the initial training data for wood samples. We present a second iteration of the test as well as a new platform for entering data and testing the algorithm, which will be made available over the internet for registered users.

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A High-Resolution Paleoenvironmental Record Based on Phytoliths from the Armenian Highlands: The Upper Paleolithic of Aghitu-3 Cave, Southern Armenia

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The rich archaeological record of the Late Pleistocene in the southern Caucasus and Armenian Highlands enhances our understanding of paleoenvironmental conditions as it allows us to interpret the behavioral patterns of the varied groups of hominins that occupied the region in the past. Building on previous research using phytoliths as a proxy for modern vegetation, this study adds phytolith analysis as a tool for studying paleoenvironmental conditions in the region Here we present paleoenvironmental results based on phytoliths analysis from Aghitu-3, an Upper Paleolithic cave site in the Armenian Highlands. Using multivariate statistics and relative abundance in conjunction with high-resolution radiocarbon dates, this study shows the environmental response to periods of rapid climate change over the 15,000-year history of the site. Despite the sudden onset of Dansgaard-Oeschger interstadial events resulting in swift temperature fluctuations on a scale of centuries, the environment in the Vorotan River Valley remained relatively consistent through the Early and Middle Upper Paleolithic from about 39,000 to 24,000 years ago. Woody vegetation from lower altitudes expanded during warmer and more humid periods, only to retreat and be replaced with steppe in conjunction with falling temperatures. Thus, the Vorotan River Valley offered resource stability during the climatically volatile period from late Marine Isotope Stage 3 leading into the Last Glacial Maximum during Marine Isotope Stage 2.

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Zooarchaeological and Taphonomic Analysis of Aquatic Faunal Assemblages in the Koobi Fora Formation

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Aquatic faunal assemblages (e.g., fish and turtles), though underexplored in research, hold potential for reconstructing hominin environments. Here we report on faunal abundances of aquatic and terrestrial fauna across two paleontological sites to help establish a baseline to be compared to archaeological sites. We collected fossil fauna from the Chari Member (1.38–0.75 million years ago [Ma]) and compared faunal abundance to 2023 data collected from the Upper Burgi Member (2.0–1.87 Ma) of the Koobi Fora Formation, Kenya. Fossil specimens were collected using a systematic method to sieve through sediment from a 2x2 meter square through wet and dry-sieving. Collected specimens were then sorted based on sieve method (wet or dry), taxa (i.e., mammal, reptile, fish), and specimen size (>2cm, 1–2cm, and <1cm). Subsamples were taken from fish specimens to determine the number of specimens that were <3mm and identifiable by taxon or skeletal element. We calculated the number of identifiable specimens (NISP) of collected fauna to make comparisons between sieve methods, sites, and specimen sizes. The Chari Member assemblage contained a higher proportion of fish specimens (>95% NISP) compared to Upper Burgi Member assemblages (>50% NISP mammals). Comparisons between sieve methods within the Chari Member sample also showed differences. The wet-sieved assemblage contributed over 48% of the total fish specimens despite only having a quarter of each square taken for wet-sieving. This indicates a loss of taxonomic information when sediment is only dry-sieved. 75% of the squares had a majority of <3mm specimens that were whole and identifiable as teeth or vertebrae that would not have been recovered using standard dry sieving methodologies. The Upper Burgi and Chari assemblages can provide new insights into hominin behavior and evolution through the greater aquatic taxonomic diversity found in these more detailed methods.

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Middle-to-Upper Paleolithic Cultural Transition in Southern Jordan: A View from the Western Hisma Area

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We present an overview of our recent investigations of Middle and Upper Paleolithic sites in the western Hisma area, southern Jordan, focusing on the chronological and lithic records in addition to analyses of faunal remains and paleoenvironment. The western Hisma area is suitable for the study of the Middle-to-Upper Paleolithic transition because of a concentration of several sites belonging to the Late Middle Paleolithic (LMP), the Initial Upper Paleolithic (IUP), and the Early Upper Paleolithic (EUP). These sites had been originally investigated by Prof. Donald O. Henry (University of Tulsa) since the 1970s (Henry 1994), and renewed fieldwork started in 2016 to increase our resolution of chronological, paleoenvironmental, and archaeological analyses. The re-excavated sites include Tor Faraj (LMP), Tor Sabiha (LMP), Wadi Aghar (IUP), Tor Fawaz (IUP), and Tor Hamar (EUP). We also discovered another IUP site, Aswad Terrace, and conducted geological surveys to clarify the distributions and availability of lithic raw material sources. Our chronological data indicate that the LMP-IUP-EUP cultural changes in the western Hisma are broadly bracketed between 50 ka and 40 ka. Analyses of the lithic technological changes focused on the development of bladelet technology, the productivity of cutting-edge length, and the lithic raw material selection. Results indicate that major changes do not coincide with the conventional MP-UP boundary but occur later in the EUP (Kadowaki et al. 2024). Although faunal remains are poorly preserved at the sites, the appearance of some marine shells indicates changes in resource procurement behaviors or social networks since the IUP (Kadowaki et al. 2019). New geo-chemical elemental and mineralogical analyses of site sediments as well as stable isotope ratios of organic carbon further elucidate the paleoecological changes that occurred during this time period.

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Context is Bone Deep: A Quantitative Analysis of Experimentally Generated Bone Surface Modifications with Applications for Developing an Open Source and Collaborative Taphonomic Database

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The emergence and intensification of hominin carnivory was likely crucial to the evolution of our own species and can be understood through the study of fossilized bone surface modifications (BSMs) created by prehistoric hominin butchers. However, behavioral inferences based on BSMs are limited by our ability to accurately identify them. Butchery BSMs are qualitatively described as having V-shaped cross-sectional profiles, high length/breadth ratios, and internal microstriations. However, other taphonomic processes create BSMs with similar morphological traits, which has led researchers to pursue new methods and criteria for BSM identification. Recent studies have attempted to improve BSM identification by collecting quantitative measurements from BSMs of known origin that are subsequently used to characterize mark characteristics through computational modeling. While these techniques appear promising, their broader application to the fossil record should require demonstration of inter-analyst reproducibility and sharing of datasets of experimentally produced BSM. This paper aims to develop an experimental and open-source database of computationally reconstructed BSMs that researchers can use and contribute to freely. This paper describes the initial development of such a database containing over 1000 3D models of BSM created under various experimental conditions, including stone tool butchery, percussive marrow extraction, carnivore and human feeding trials, and ungulate trampling. All BSMs were digitized and modeled in 3D using high-resolution profilometers and measured following the highly replicable BSM modeling methodology in Pante et al. (2017). Multivariate Bayesian statistics applied to these measurements can differentiate the taphonomic agents that created each BSM with high accuracy, highlighting the potential for this technique to be applied in fossil BSM identification.

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Multiproxy Analysis of Ethnographic Ostrich Eggshell (OES) Dancing Rattles: Identifying Criteria for Inferring Musical Accompaniment and Dance in Prehistory

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Music is a universal behavior in human cultures. However, early archaeological evidence of music is limited, partially due to the ephemeral nature of many instruments. In present-day southern Africa, the San people use ostrich eggshell (OES) fragments to create leg- and ankle- rattles for musical accompaniment during recreational dancing and ritual healing. OES fragments are inserted into dried cocoons of the silk moth (*Lasiocampidae*), which are harvested from Acacia trees. These rattles are also depicted in rock art and appear in archaeological deposits dating approximately 3,000 years ago. OES fragments are abundant at many archeological sites, possess high preservation potential, and can be directly dated, providing a unique avenue to identify these rattles in prehistory. To categorize use-wear produced by rattling, we analyze an ethnographic assemblage of OES fragments used in San Rattles. The OES were rattled for varying amounts of time, ranging from weeks to years, and new fragments incorporated into the cocoons during use. We examined these fragments using light and confocal microscopy to document changes in the surface roughness and appearance, and generated measurements with calipers and ImageJ to assess shifts in size. Our results reveal a clear progression of surface modification over time, with distinct phases separating the groups, which we categorized as *Lightly Rattled*, *Moderately Rattled*, and *Heavily Rattled*. Kruskal-Wallis and Dunn's Post-Hoc tests demonstrate a significant difference ($p=<0.05$) between the groups in terms of size and surface roughness parameters. Over time, OES fragments become smaller, thinner, and more circular, and the surfaces lose identifying features due to increasing abrasion. This analysis suggests that Heavily Rattled OES is distinctive enough to be identified in archaeological context, providing a means to trace the antiquity of leg and ankle rattles, and offering new insight into the role of music and dancing in prehistoric societies.

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Balancing the Scale: Examining the Environmental Implications of Taxonomic Abundance and Herbivore Enamel Values Across Space and Time

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A growing body of research has emphasized the need to understand the spatiotemporal scales of the environmental signals preserved in paleoenvironmental proxies. This understanding is essential for aligning paleoecological research questions with the appropriate scales of the available data. Taxonomic abundances and herbivore enamel carbon isotope ($\delta^{13}C$) values are two common proxies for reconstructing paleoenvironmental conditions from the mammalian fossil record. Though both proxies are ultimately derived from the same source (i.e., vertebrate fossils), it is likely that they are recording the environment at different spatiotemporal scales. Taxonomic abundances are expected to reflect a smaller spatial scale but a larger temporal scale since differences in abundance should arise from ecological (e.g., habitat preferences) and broader taphonomic (e.g., depositional environments, fossil accumulation) processes. In contrast, herbivore enamel $\delta^{13}C$ values are expected to reflect the environment over larger spatial scales but smaller temporal scales because they form over the course of tooth development as large herbivores range across broad portions of the landscape. To explore how spatiotemporal scale influences the interpretations of these proxies, we evaluate how faunal abundances and the distribution of herbivore enamel $\delta^{13}C$ values vary across depositional contexts in the Koobi Fora Formation, northern Kenya, ca. 1.98–1.38 million years ago. We analyze sedimentary facies to characterize depositional contexts and evaluate the differences in distribution of taxa and functional groups across depositional contexts through time. Then, based on the taxonomic makeup of faunal communities, we generate distributions of $\delta^{13}C$ values to determine whether distinct faunal communities would produce different isotope profiles. Results show significant differences in taxonomic and functional group abundances across depositional contexts through time, yet $\delta^{13}C$ values exhibit substantial overlap across these contexts. These results suggest that commonly employed proxies are recording environmental signals at different spatiotemporal scales that must be considered before drawing conclusions about paleoenvironments.

Paleoenvironmental Reconstructions of Gona, Ethiopia, Between 3–1 Mya: Evidence from Faunal Community Analysis

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The Plio-Pleistocene, specifically between 3 and 1 Ma, is important for understanding major technological, behavioral, and anatomical transitions in the evolution of early *Homo*. Specifically, the origin of the Oldowan and the appearance of the Acheulian industrial complexes were significant for early hominin ecological adaptations. The advent of tool-making has long been associated with expanding grasslands in Africa. Due to the scarcity of fossil and artifact-bearing deposits, little is known about the paleoenvironment during this time. Gona, located in the Afar Rift Valley in Ethiopia, provides a unique window for examining the context in which these changes occurred. The study area has fossil and archaeological deposits spanning the past ~6.4 million years and arguably the longest continuous record of Early Stone Age (ESA) archaeology in the world, including the earliest confirmed evidence of carcass processing in the archaeological record (Domínguez-Rodrigo et al. 2005; Semaw et al. 1997; 2003) and among the earliest Oldowan and Acheulian assemblages. This study presents community assemblage data from Artiodactyla, Perissodactyla, Proboscidea, and Primate fossil specimens from >30 localities in the Gona study region dated 3–1 Ma. These analyses support previous findings from analyses of Bovid tribal abundances and $\delta^{13}C_{enamel}$ as additional evidence for a nuanced heterogeneous landscape through time. These paleoenvironmental reconstructions provide unparalleled context for the Early Stone Age assemblages at Gona and insights into hominin-environment interactions of early stone tool use.

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Bone Tool Technologies in the Kasitu Valley, Northern Malawi

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The Kasitu Valley in northern Malawi, within the Zambezian open woodland belt of southern-central Africa, provides a rich archaeological record for exploring forager lifeways during the Middle and Later Stone Age. Our study analyzes bone tools yielded from Hora 1 and Mazinga 1, encompassing 79 specimens from HOR-1 (dating mostly to the period between 8–21 thousand years ago [ka]) and 375 from MAZ-1 (dating from recent times to ~37 ka). These assemblages span the Pleistocene-Holocene transition and reveal a remarkable diversity in tool forms and a wide repertoire of bone tool manufacturing techniques. The study shows the evolution of bone tool manufacturing techniques in the region, including local technological innovation. It provides a new insight into the significant role of bone tools in ancient hunter-gatherers' subsistence strategies and cultural behaviors in an understudied part of Africa.

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Flint Scrapers in the Levantine Late Acheulian and Their Implications for Acheulian Cultural Conservatism

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Cultural conservatism and enduring technological continuity with minimal change characterize the Acheulian Complex of the Early Paleolithic Old World. In the Levant, the Late Acheulian (500–200 kya) is also associated with the gradual incorporation of lithic innovations, such as the proto-Levallois method, into traditional technological trajectories. This presentation will focus on another Late Acheulian innovation—the emergence of Quina-like scrapers, which are primarily associated with post-Acheulian industries—the Acheulo-Yabrudian of the Middle Pleistocene Levant and the Mousterian of Late Pleistocene Europe. Our investigation of the Late Acheulian sites at Jaljulia, covering a timespan of 500–200 kya, demonstrated that Quina-like retouch emerged during the earliest occupational phases, alongside the production of archaic large-flake scrapers and typical Acheulian scrapers. Our observations indicate that scrapers with distinct working edge attributes share similarities in production methods and were functionally dedicated to the scraping of soft materials. In addition to Quina-like scrapers, the Late Acheulian assemblages from Jaljulia feature several other technological innovations and atypical trajectories, such as the small-scale production of bifacial knives and Amudian blades. These Late Acheulian innovations in the Levant experienced varying degrees of development—some were widely adopted in successive cultural entities, while others vanished with the Acheulian industries. Our findings challenge the perception of Acheulian technological stagnation, underscoring the ability of Late Acheulian hominins to integrate innovations within traditional, accumulated technological frameworks.

An Assessment of Stature and Ecogeographic Profile of Human Remains from A Medieval Burial in the Central Highlands of Kenya

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This study involves an assessment of the stature and ecogeographic profile of a human skeleton KNM-GT 77350 from a Medieval burial found in the Central Highlands of Kenya. The specimen from a new Kalulu site was excavated from a double burial composed of a more complete skeleton with postcranials nicknamed, the Kalulu 1 and another accompanying skull the Kalulu 2. The burial is radiocarbon-dated to approximately 1,000 years AD. The long bones were used in this study to estimate the stature and ecogeographic adaptations using published methods. Stature estimates applied equations by Sjøvold, (1990) for long bones such as the humerus, the femur, and the tibia. The modern human height classes were evaluated using published references. The crural index of Kalulu 1 was calculated and compared with skeletal data of modern and archaeological samples derived from the circumpolar, temperate, and tropi-

cal regions around the globe. These comparative samples allow body segmentation assessment to determine the ecogeographic adaptations for these remains found in the tropics, but in an area experiencing low mean annual temperatures because of Mount Kenya and the Aberdare Ranges that have influenced the area for over two million years. A stature of 174.1cm is estimated for the KNM-GT 77350 specimen. This is a "tall height" if male and "very tall height" if female, based on height classes of recent *Homo sapiens*. The crural index of 85.4 for the Kalulu 1 specimen is within the range of African and Australian populations but is significantly different from those of Alaskans, Asians, and Europeans. The results indicate a tropical body segment despite living in the highlands with low ambient temperatures. This study contributes to the population substructure debates and concludes that the evolution of body segments may be driven by latitude and not low mean temperatures alone.

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Zooarchaeology and Paleoenvironmental Reconstruction of Archaeological Levels at Arma Veirana Cave, Italy

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Palaeoecological reconstruction and taphonomy are critical for understanding and contextualizing archaeological sites. ***Arma Veirana*** is a cave site in northwestern Italy in the region of Liguria that preserves rich archaeological deposits that extend beyond the range of radiocarbon dates and later strata that date to the Pleistocene/Holocene boundary. Previous analyses have focused solely on the Black Mousterian archaeological level and its zooarchaeological content. This analysis provides preliminary analyses of the most prevalent (exceeding 200 data points) subsequent stratigraphic levels including the contact layer between the Black Mousterian layer and the Granular layer, the Granular layer itself, and the Rocky Brown layer. Each stratigraphic level has been analyzed for body size, taxonomy, and bone element representation. An analysis of maximum burning stage in relation to body size was also completed. The Granular level included a total of 300 specimens, the Black Mousterian contact layer 283, and the Rocky Brown 211. The Granular level exhibits a lower number of specimens included in body sizes 1 and 4 compared to the Contact and Rocky Brown layer, however, the Rocky Brown layer includes a body size category of 0, which the others do not, possibly skewing these results. The Granular and Rocky Brown levels exhibited higher cranial fragment representation compared to the contact layer. Beyond the categories of unidentifiable and generally mammalian, all three levels ubiquitously indicate that cave bears frequented and/or inhabited the cave, consistent with findings from the Black Mousterian analyses.

Indications of Bovid Mortality Profiles from FwJj80 in Area 8A Koobi Fora

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Numerous Pleistocene archaeological sites indicate that animal products were a part of hominin diets, yet the details of this behavior remain poorly understood. Increased meat consumption is thought to have influenced significant biological and behavioral changes in early *Homo*, and an early Pleistocene faunal assemblage from FwJj80 in Area 8A, East Turkana, provides key evidence for how early hominins acquired and processed animal resources during this pivotal time in human evolution. This assemblage, which predates more extensively studied zooarchaeological sites in the Okote Member of the Koobi Fora formation (1.6–1.4 Ma), provides critical insights into early hominin meat consumption and carcass accumulation patterns and fills a temporal gap in our understanding of early hominin carnivory in East Turkana. The presence of hominin dental remains and tool-inflicted bone modifications, along with minimal evidence of carnivore activity, suggests that hominins played a significant role in carcass processing with limited competition from predators. Our research at this locality included a mortality profile analysis, applying a modified coding system to provide age estimates for isolated bovid teeth. We compared the data from FwJj80 to bovid mortality profiles from three contemporaneous faunal assemblages—Kanjera South, Kenya (~2.0 Ma), FLK-Zinj, Tanzania (~1.84 Ma), and the Olduvai Background Assemblages, Tanzania (~1.88–1.79 Ma), as well as modern carnivore accumulated assemblages. Our findings reveal a dual foraging strategy. Small bovids were predominated by juveniles, a pattern consistent with Kanjera South and interpreted as evidence of vulnerability-based hunting. Medium-sized bovids, in contrast, were dominated by prime-aged individuals, a hallmark of selective hunting by hominins.

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Functional Traits Predict Predator-Prey Relationships in African Mammals

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Predation by *Homo erectus*, either alone or synergistically with climate change, has been suggested to play a decisive role in the loss of Africa's largest herbivores and carnivorans during the early Pleistocene. Teasing apart the effects of environmental change and hominin impacts on these losses requires that researchers move beyond the conventional 'pattern-matching' paradigm whereby extinctions are correlated with archaeological or environmental datasets. A more powerful approach that has been increasingly utilized by anthropologists incorporates food web theory, which provides a mechanistic test of these differing hypotheses. A major challenge to these food web reconstructions is modeling predator-prey interactions between extinct species. Predator and prey body size is a well-known predictor of these relationships, but other functional traits of both herbivores and carnivorans have the potential to refine them. Here, we build a random forest model incorporating functional traits such as body mass, predation strategy, dietary category, and substrate use to predict predator-prey relationships. This model is built on the CarniDIET dataset, which records thousands of predator-prey relationships between extant African mammalian taxa. We find that predator body mass is the strongest predictor of a predator-prey link, but when only predators above 21.5kg are included, other functional traits such as predation strategy (ambush, pounce/pursuit, pursuit) and prey dietary guild (browser, grazer, mixed feeder) rise in importance. We then apply this model to carnivoran and herbivore species in the KBS member of the Koobi Fora Formation to predict predator-prey relationships. When compared to modern ecosystems, the KBS paleo-community has a higher mean niche overlap between carnivoran species. This implies greater connectivity and therefore robusticity in the early Pleistocene food web relative to today, meaning that an incursion by *Homo erectus* or climate change alone might not have been enough to cause the large-scale extinction of African megafauna.

Distinguishing Bone Retoucher Marks from Other Bone Surface Modifications

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The use of bone as a soft hammer for shaping and sharpening stone tools, a technology known as bone retouchers in the European literature, is considered a benchmark for behavioral modernity of post-Acheulean hominins at Paleolithic sites. Despite the presence of bone technology in the early Pleistocene sites of Africa, there is currently no evidence of bone having been used to shape and sharpen stone tools. This may in part be due to the absence of a reliable way to distinguish bone retoucher marks from both carnivore tooth marks and other types of human-induced marks, the qualitative characteristics of which have been shown to overlap with one another. Here, we introduce a quantitative and replicable micromorphological approach for identifying bone retoucher marks. Actualistic experiments using cow and zebra bones to bifacially resharpen large cutting tools were carried out and bones were collected, curated, and inspected for impact marks. Individual marks were molded and subsequently 3D scanned using a Sensofar S Neox 3-D optical profilometer. Micromorphological measurements of the marks were collected using Digital Surf's Mountains® software and statistically compared with marks of known origin including cut marks, percussion marks, mammalian and reptilian tooth marks, and ungulate trampling marks. Results show that bone retoucher marks are distinct from other mark types allowing their identification on fossil specimens. Future work should focus on the application of this technique to the fossil record to understand the origin of bone retoucher technology and its importance to the cultural and behavioral evolution of our ancestors.

Differential Effects of End-Pleistocene Climate Change and Early Humans on Megafaunal Spatial Distribution in the American Southwest

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The end of the Pleistocene is characterized by pronounced climate change, human arrival and dispersal, and the extinction of a variety of taxa, the majority of which were mammals. During this period, the continent experienced the loss of thirty-eight genera of mammals, over 70% of which are classified as megafauna. Historically, the cause of these extinctions has been attributed to a singular factor—either climate change or human hunting. Recently, however, studies featuring a multi-causal framework have become more popular. This research utilizes such a multi-causal framework by examining how both climatic shifts and the arrival/expansion of human populations during the terminal Pleistocene and into the early Holocene affected the spatial distributions of various megafaunal taxa in the American Southwest. The spatial distributions of the most represented megafaunal taxa (e.g., *Mammuthus, Mammut, Camelops, Equus*) shift latitudinally through time, though specific correlations between climatic events and human presence appear to vary between each taxon.

Virtual Edges: Finite Element Analysis (FEA) insights from the Late Lower Paleolithic (LLP) Lithic Assemblage from Dalarik 1 Cave

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Lithic replicative experiments, though valuable for advancing knowledge, are limited by constraints in accurately reproducing stone tools. Controlled experiments often rely on uniformitarian principles but fail to replicate stone implements. Both sets try to bridge artifacts and interpretations without directly testing archaeological material. We propose an innovative approach to tackle this issue by applying Finite Element Analysis (FEA) to lithic artifacts. This approach enables virtual experimentation and precise mechanical modelling directly on 3D meshes of both experimental and archaeological artifacts. By complementing traditional analyses, it offers fresh perspectives on tool design, performance, and the life history of tools. Our study focuses on two sample sets from the lithic assemblage from LLP Dalarik-1 cave, Armenia, which includes both transversal scrapers (unifacial edges) and bifaces (bifacial edges) made of obsidian within the same archaeological horizon and standard geometric samples representing the same edge types. Our simulations reveal the relationship between edge geometry and stress resilience. This explores geometric differences in stone tools, which could not merely be cultural markers but reflect deliberate design choices to optimize tool performance, efficiency, and durability. The use of glass in our experimental models addresses material property considerations, providing a consistent baseline for comparison with the obsidian artifacts from Dalarik 1. The results highlight the applicability of FEA in lithic studies, providing a non-destructive method to analyze the mechanical properties of stone tools and infer their functional roles. This approach facilitates a deeper understanding of decision-making processes and technological innovations in prehistoric societies. By integrating engineering methods into archaeological research, we can reassess artifact design principles and contribute to discussions on tool life cycles, including retouching and maintenance strategies. This study underscores the potential of virtual experimentation to expand our analytical capabilities, bridging the gap between artifact form and function and providing new insights into the decision-making of past hunter-gatherers.

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Local Habitat Heterogeneity Characterized the Southern African Middle to Later Stone Age Transition: Introducing Generalized Additive Mixed Models to Carbon Isotope Paleoecology

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The Middle to Later Stone Age (MSA to LSA) transition in southern Africa represents a profound shift in technology and social organization characterized by increases in population sizes, artifact densities, and frequencies of material symbols. Recurrent stadial periods associated with global cooling, most notably the Last Glacial Maximum (LGM: ~24–17 ka), have been closely linked to these broad cultural changes. MSA/LSA behavioral transitions, however, cross-cut southern Africa's highly variable environments, hinting at a complex interplay of climatic and social factors. Faunal enamel isotopes are one widespread proxy for local environmental conditions. However, the relationships between specific climatic variables and fossil ungulate enamel isotope values remain elusive; it is thus difficult to interpret how directly carbon enamel isotopes ($\delta^{13}C_E$) reflect specific climatic changes. In order to characterize spatio-temporal variation in enamel isotopes from MSA/LSA transitional assemblages and understand the local effects of the LGM, we develop a novel application of generalized additive mixed models (GAMMs) to the $\delta^{13}C_E$ record of terminal Pleistocene southern Africa, ~40–11 ka. By incorporating site, age, and taxa as model parameters, GAMMs simultaneously consider the influence of dietary and climate components, representing global to local scales, on the variation in $\delta^{13}C_E$. Our results provide evidence of spatial variation in $\delta^{13}C_E$ among sites caused by differences in the manifestation of the LGM across the subcontinent. They demonstrate the strength of local ecosystem controls on vegetation structure over regional climate change, and support hypotheses that the emergence of a cohesive LSA toolkit was more a function of social coalescence as a response to divergent local experiences rather than adaptation to similar environmental conditions.

The Secret Lives of Paleolithic Teens: Assessing Puberty Status in a Sample of European Upper Paleolithic Adolescents

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Childhood and adolescence are two life-history stages that are either unique to humans, or significantly expanded in the human life course relative to other primates. While recent studies have deepened our knowledge of childhood in the Upper Paleolithic, adolescence in this period remains understudied. Here, we use bioarchaeological maturational markers to estimate puberty status of 13 Upper Paleolithic adolescents from sites in Russia, Czechia, and Italy to: 1) evaluate the feasibility of the application of bioarchaeological puberty assessment methods to Upper Paleolithic (*Homo sapiens*) skeletal individuals, and 2) estimate the timing and tempo of puberty in Upper Paleolithic adolescents. Although variable, our results revealed that puberty had begun by 13.5 years of age for the majority of individuals suggesting that rather than being precocious, today's adolescents are following a blueprint for puberty that was established thousands of years ago. Assessing the age of menarche was difficult due to the paucity of female adolescents, but based on the available evidence, it appears to have occurred between 16 and 17 years of age. For some, full adulthood was achieved by 17–22 years, similar to the patterns seen in modern wealthy countries and in advance of historic populations living in urbanized environments. The bioarchaeological analysis of puberty among Upper Paleolithic adolescents has important implications for the study of the emergence of adolescence within human-life histories, as well as for understanding the developmental plasticity of sexual maturation across past and present human populations. Finally, osteobiographical data in conjunction with ethnographic data are used to create a model of what life might have been like for Upper Paleolithic "teens."

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Site Formation Processes and Diagenetic Pathways Through the Geoarchaeological Study of Bone Remains

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Decoding site formation processes through geoarchaeological approaches is fundamental component of archaeological and Paleolithic research. The geoarchaeological toolkit typically includes soil micromorphology and complementary bulk analyses, such as sedimentological, mineralogical, chemical, magnetic, micro-archaeological, and geochronological methods. The successfulness of such frameworks in the decipherment of depositional mechanisms has been demonstrated through numerous applied studies over the last few decades. Archaeological bones, crucial for our understanding of aspects of past human behavior, especially subsistence strategies, can be additionally perceived as an independent archive of the depositional milieu. The impact of syn- and post-depositional processes is often well-imprinted on the different degrees of preservation of osseous fragments. Therefore, the disentanglement of their diagenetic histories can be highly informative for the reconstruction of the sites' formation processes. In this paper we propose a methodological framework for the study of bone fragments using a geoarchaeological perspective. This includes macroscopic observations of bone taphonomy and a series of micro-analytical techniques, centered by micromorphological and histological analyses, elemental and mineralogical mapping through SEM-EDS, and micro-FTIR. Additional analyses on bulk sediment and bone samples through XRD, ATR-FTIR, and ICP-MS are incorporated. The methodology will be implemented for the study of two cave sites from Ararat Depression, in Armenia, Dalarik-1 and Ararat-1, representing the end of the Lower and the Middle Paleolithic. The differential geological setting of the two caves, situated in volcanic (basalt) and sedimentary (limestone) lithologies offers a comparative basis for the exploration of diverging diagenetic trajectories of bone fragments through time.

Functional Morphology of ~2.0 Million-Year-Old Hominin Hand and Foot Remains from Drimolen Main Quarry, South Africa

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The Drimolen paleocave system is located in Gauteng Province, South Africa. The Drimolen Main Quarry (DMQ) dates to approximately 2.0 million years ago and has produced numerous craniodental remains of *Paranthropus robustus* with a smaller number attributed to early *Homo*. Isolated postcranial remains have also been recovered and here we analyze anatomically informative hand and foot bones from the DMQ to provide insights into the functional morphology of the Drimolen hominins. Overall, the remains are small, similar to most early hominins. Four manual middle phalanges vary in overall length but can be accommodated within a single taxon and possibly a single hand (i.e., different rays). Well-defined insertion pits for the *flexor digitorum superficialis* flank a prominent median bar in all specimens. One complete manual proximal phalanx and two partial specimens exhibit only modest longitudinal shaft curvature and development of the flexor sheath ridges (well within the range of recent *Homo sapiens*). In overall form, the phalanges are like those from nearby Sterkfontein and Swartkrans suggesting a generalized anatomy that cannot be attributed to a specific taxon; however, the morphology suggests a lesser degree of arboreal adaptation than is seen among some hominins such as *Australopithecus afarensis*, *A. sediba*, or *H. naledi*. A single non-hallucal pedal phalanx shows a similar signature with modest shaft curvature and a dorsally-canted metatarsophalangeal joint typical of terrestrially-committed bipedal hominins. However, a proximal hallucal metatarsal suggests a mixed signal with curvature of the proximal articular facet that falls outside the range of *H. sapiens* and overlaps gorillas, possibly reflecting increased hallucal divergence or loading mechanics of the first tarsometarsal joint that are distinctive from humans. These results might reflect differences in the two known DMQ taxa or could suggest mosaicism in the evolution of manual and pedal adaptations near the divergence of *Paranthropus* and *Homo.*

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A Quantitative Analysis of *Homotherium Serum* Tooth Marks

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Humans have coexisted with large predators, such as sabretooth cats, throughout their evolutionary history. Sabretooth cats played a significant role in their ecosystems as carnivores specialized in consuming the flesh of their prey while avoiding bone consumption. These behaviors likely left scavengeable resources, such as bone marrow, for other species. However, because sabretooth species are extinct, their impact on the fossil and archeological records remains underexplored. Thus, this study examines bone marks from the fossil assemblage at Friesenhahn Cave, Texas, which has been interpreted as a ~19 ka *Homotherium serum* den. This assemblage is valuable as the cave has yielded no evidence of human interaction with the skeletal material, providing a rare opportunity to study sabretooth tooth marks without the risk of misidentification. To analyze these marks, a confocal profilometer was used to create 3D models, which were then measured and compared to a database of experimentally produced bone surface modifications (BSM), including marks from modern carnivores and stone tools. The analysis aims to characterize extinct carnivore tooth marks and determine whether sabretooth marks are distinct. This work has implications for the degree to which researchers will need to rely on associated contextual evidence when determining if sabretooth cats were responsible for carcass processing and may have an impact on previously hypothesized feeding behaviors and ecological roles for *H. serum*, especially in environments shared with hominins.

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Changes in Hominin Land-Use Through the Oldowan to Acheulean Transition at Olduvai Gorge, Tanzania

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Olduvai Gorge, Tanzania, holds a central place in our current understanding of the evolution of hominins in the early Pleistocene. The oldest stratigraphic units at Olduvai, Beds I and II (~2.03–1.14 Ma), encompass a time period containing key evolutionary and cultural transitions within our lineage. These include the appearance of *Homo erectus*, the development of the Acheulean lithic industry, and potentially the expansion of hominin carnivorous behavior. The broader behavioral changes indicated by these transitions would have altered hominin activity patterns at multiple, archaeologically visible spatial scales. While comparisons have been drawn between specific archaeological sites within Beds I and II Olduvai, relatively little work has been done that analyzes how hominin presence and land-use across the Olduvai basin would have changed through time as a result of these shifts. Drawing on decades of paleoanthropological data from the sites, paired with high-resolution surficial and UAV-based stratigraphic mapping, we investigated the spatial changes in the traces of hominin activities at Olduvai across the Oldowan-Acheulean transition. Using geospatial methods, excavation locations were mapped and weighted by a number of different archaeological and taphonomic proxies, including fossil and lithic density and butchery mark frequency. This provided a visual measure of where hominins were concentrating their activities, beyond presence and absence. Our analysis demonstrates notable changes in the broader pattern of hominin activity locations between Bed I and Bed II times, even after controlling for sampling strategy and outcrop exposure. In Bed I, the locations with traces of hominin activities are more clustered and limited in their spatial distribution on the paleo-landscape, while in Bed II they are more abundant and widely dispersed. This suggests that the hominins later in the sequence were less spatially constrained in their environment and may have played a different ecological role at Olduvai than earlier hominins, becoming a more competitive presence on the landscape.

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A Comparative Analysis of *C. crocuta* and *H. hyaena* Chewing from Two East African Assemblages

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Differentiating the actors that modify paleontological and archaeological bone assemblages has been a goal relevant to many interpretations of the past. This study makes use of a new method introduced by Pobiner et al. (2020) to quantify chewing damage done by two different members of Hyaenidae. The goal of this research is to test whether use of this method can successfully distinguish between two geographically overlapping members of the same carnivore family. Two carnivore assemblages were used to accomplish this—one experimental assemblage created by Sal Capaldo in Tanzania for his dissertation and modified by *Crocuta crocuta*, the other a natural *Hyena hyena* den assemblage recovered from Kenya. Both species have specialized bone cracking/crushing adaptations. Even with this shared adaptation, there is a noticeable difference between the damage to prey bones caused by these two species. The larger tooth and jaw morphology of *C. crocuta* allow them to cause more damage to the bones, which they often completely consume. *H. hyaena* are smaller and often lone scavengers limiting the damage they can cause, especially to larger sized prey. This can be potentially difficult with smaller sized prey as both *C. crocuta* and *H. hyaena* are capable of completely consuming skeletal material. Nonetheless, this study shows that when comparing chewing damage caused to *Capra hircus* and *Ovis aries*, the two hyaenid species have visibly different chewing patterns.

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Serially Sampled Carbon, Oxygen, and Strontium Enamel Isotopes of Late Pleistocene *Mammuthus* and *Bison* from Central Texas

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Globally, ungulate migrations are disappearing or decreasing at an alarming rate (Harris et al. 2009). Xu and colleagues (2021) documented changes in migration in 27 ungulate species across the globe in response to anthropogenic and "natural" changes. Migrations provide seasonal food influxes for predators and are important for nutrient cycling within an ecosystem due to death and defecation. Stable isotope ecology can reveal these processes in the present and past and further our understanding of large mammal movement patterns and impacts. Our study examines *Bison* and *Mammuthus* from three Late Pleistocene sites in central Texas. We serially sampled enamel carbon ($\delta^{13}C$), oxygen ($\delta^{18}O$), and strontium ($^{87}Sr/^{86}Sr$) isotopes of two *Mammuthus* and four *Bison* molars. Stable enamel carbon and oxygen isotopes are often used as proxies of diet and drinking behavior and surface water in paleoecology, respectively; strontium isotope values are used to estimate movement. Three of the four *Bison* molars display inverse patterns between their carbon and strontium isotopes, but a direct pattern between their oxygen and strontium isotopes. Alternatively, a *Mammuthus* specimen has similar patterns between their carbon, oxygen, and strontium isotopes, while another shows similarity in only their carbon and oxygen isotopes. Our study found similar strontium ratios east and west of our sites, while interpolated mean annual precipitation $\delta^{18}O$ values for present-day Texas decrease along a gradient from southeast to northwest. At least one of our sampled *Bison* has isotope values consistent with hypothesized movement between the Texas Gulf Prairie and more-inland areas. Another bison shows little strontium variation but high variation in oxygen signal suggesting a north to west gradient that would be consistent with the strontium value. Our study reinforces the value of combining strontium isotope serial sampling with carbon and oxygen serial sampling for clarifying paleomovement patterns.

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Reindeer Taphonomy and the Role of Canids at the Purported Early Dog Domestication Site of Předmostí, Czech Republic

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Morphological, isotopic, and dental microwear analyses of the ~26,000–29,000-year-old Předmostí canid fossils support what some interpret as the earliest evidence of dog domestication. The 'protodog' morphotype had a reindeer-based diet (isotopes) with greater hard part consumption (dental microwear) interpreted as more tooth-on-bone contact during feeding, with wolves having fed on mammoth with less tooth-on-bone contact. We hypothesized that wild canids would have been unlikely to modify prey bone at this open air, year-round occupational site, with tooth-marked reindeer bones indicating the presence of protodogs. Only 4.4% of 1,275 reindeer bones and antlers retained taphonomic evidence of carnivore modification. This is low compared to captive wolf studies, while wild wolf studies have varied in bone modification frequency and intensity. Feral dog studies that may provide a better analogue to protodogs are lacking. However, carnivore modification percentages were higher for certain elements: femur (15.7%), radio-ulna (11.3%), indeterminate long bone fragments (8.6%), and tibia (7.4%). 16.2% of all reindeer specimens retained butchery marks with 3.4% of those also preserving tooth marks. Tooth marks on long bones were limited to the epiphyses and, with 12.5% of carnivore modified specimens also exhibiting butchery marks, supports humans-to-carnivoran access to reindeer carcasses. Importantly, 7.9% of antlers were gnawed and could be interpreted as boredom chewing, as has been observed at wolf den sites and by domesticated dogs. Boredom chewing would not be expected by wild canids scavenging from a human habitation site. The assemblage is heavily root-etched, and a conservative approach was taken in identifying all marks such that overall recorded mark numbers may be artificially low. Still, this study indicates that carnivoran involvement is evident at the site. Future taphonomic studies will include musk ox, horse, and mammoth to further determine what level of involvement carnivorans, inferred here as protodogs, had at Předmostí.

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Ancient Collection, Fresh Insights: Revisiting the Lithic Technologies at the Middle Paleolithic Nahr Ibrahim Cave, Lebanon

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The archaeological cave complex of Nahr Ibrahim in Lebanon is one of the few sites frequently referenced in the literature as part of the Levantine mid-Middle Paleolithic, primarily associated with the Marine Isotope Stage (MIS) 5. This chrono-cultural context, marked by favorable climatic conditions that likely facilitated population movements within the Levantine region, offers a dynamic framework for exploring the mechanisms driving technological diversity and consistency in human behavior. Therefore, the Nahr Ibrahim site, excavated over 50 years ago by Prof. Ralph S. Solecki, and which has yielded a substantial collection of lithic artifacts, presents an excellent opportunity to reassess technological organization within the context of the mid-Middle Paleolithic period, particularly in the central Levantine region. As archaeological research continues to advance in this region and its neighboring areas, there is increasing recognition of the importance of reexamining established sites to gain new insights into the technological and technical practices of ancient human populations. This presentation will discuss the ongoing data collection from the lithic assemblage of the Main Gallery at Nahr Ibrahim, housed at Texas A&M University, along with the valuable archival materials from three seasons of fieldwork (1969, 1970, and 1973), which are stored at the National Anthropological Archives, Smithsonian Institution. The refined lithic technological data from Nahr Ibrahim Cave, combined with a comparative study of other Levantine sites, aims to explore potential inter-regional population interactions and movements between the central and southern Levant.

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Human Landscape Use during the Middle Stone Age of Northeast Africa: New Research in Wadi El-Hudi Southeast of Aswan, Egypt

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Human behavioral adaptation to diverse landscapes during the MSA has been one of the major research subjects in paleoanthropology. Among more prominent models are those that came from the Nile Valley and the surrounding deserts in Egypt, like the Western Desert near Abydos (Olszewski et al. 2010a; 2010b) and the Kharga-Dakhleh Depressions (Hawkins 2010; Kleindienst 2003). Even though the research on Pleistocene contexts in northeast Africa has a long history, systematic and high-resolution field campaigns like these have been rare. These models tell us that during the MSA human groups engaged in combinations of provisioning of places and individuals including either higher (Olszewski et al. 2010a; 2010b) or lower (Van Peer 2001) residential mobility. Some of these models oppose each other, but they all outline some kind of a strategic response to landscape topography, raw material distribution, and distance to water sources of the Nile, adjacent wadis, and desert oases. Here we present results of new landscape-scale research on the MSA of Wadi el-Hudi in the Eastern Desert southeast of Aswan. During two field campaigns, we documented and sampled numerous high- and low-density open-air lithic accumulations, some located at raw material outcrops, while some outside of these stone sources. Unusually high quantity of the retouched component for the MSA of Egypt, diversity of flaking technologies used (Levallois, bipolar, informal-bidirectional, etc.), and so-far undocumented pointed forms are some of the major technological characteristics of this landscape lithic record. We modeled stone procurement, flaking intensity, lithic movement, stone re-use, and tool curation in relation to raw material locations, and with respect to landscape formation processes, to assess the strategic character of landscape use in this broader region during the MSA. The results have direct implications for the research on the evolution of human behavioral flexibility and the possible role of random, opportunistic, and non-strategic behavior in this evolution.

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Body Mass Estimates of Fort Ternan Artiodactyls (Middle Miocene, Kenya) Using Long Bones

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Recent evidence shows that heterogeneous habitats with C_4 grasses had begun to proliferate by the Early Miocene, but studies of dental paleoecological proxies through the Middle Miocene suggest that bovid diets had not yet significantly expanded to include committed grazers. Because body mass is broadly correlated with diet (grazers being typically larger) body mass distributions may offer additional evidence regarding how and when Middle Miocene bovids adapted to increasing environmental heterogeneity. Here we conduct body mass estimation for bovid fossils from Fort Ternan, Kenya. We collected 3D texture scans of long bones (including femora, tibiae, and metapodials), then applied published body mass estimation schemes (Köhler et al. 2008) to reconstruct body sizes using linear measurements. Our results indicate that there was significant variation in body mass between bovids (ranging from 20.7kg in *Kipsigicerus labidotus* to 71.9kg in *Gentrytragus thomasi*), corresponding well to known characteristics of the attributed species. In *K. labidotus* in particular, three independent estimation schemes on different elements produced similar results, indicating that body mass estimation on lone and/or poorly associated skeletal elements can produce consistent results for primitive bovids. While few Fort Ternan bovids approached the size of extant bovini, primitive bovids had a wide range of body sizes despite their homogeneous dental dietary reconstructions. Body mass estimation together with postcranial ecomorphological proxies can be used to examine the timing, proportion, and adaptive impacts of the spread of C_4 grasses in Early and Middle Miocene Africa.

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Sonstraal: An *In Situ*, Open-Air Acheulean Occupation in the Southern Kalahari Desert, South Africa

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Arid and semi-arid environments have played a pivotal role in shaping the evolutionary trajectory of our species. Many key technological innovations over the past 1 million years are associated with dryland ecosystems, underscoring the importance of understanding human adaptations in these landscapes. This study presents new insights into Pleistocene behavioral adaptations at Sonstraal, a recently excavated site in the Tswalu Kalahari Reserve, Northern Cape, South Africa. The stratified deposits at Sonstraal preserve evidence of Acheulean and Middle Stone Age (MSA) occupations beginning over 780,000 years ago. Multidisciplinary analyses of phytoliths, diatoms, and lake sediments reveal that the Acheulean occupation was situated adjacent to a substantial yet shallow paleolake, providing critical water resources in an arid setting. These findings contribute to our understanding of early human strategies for coping with environmental variability, including the exploitation of ephemeral water sources. The stratigraphic and paleoenvironmental data from Sonstraal also shed light on the Acheulean-to-MSA transition, a pivotal period in the evolution of complex behaviors and technologies. Sonstraal builds on the growing body of evidence from open-air sites in the southern Kalahari, offering a rare glimpse into how early humans navigated arid environments and interacted with changing landscapes. This research highlights the dynamic interplay between human technological innovation and environmental context, emphasizing the importance of arid environments for our broader understanding of human-environmental dynamics in the Middle Pleistocene.

The Dynamic Character of the Early Middle Paleolithic at Tabun Cave and its Implications for Hominin Dispersal and Interaction in the Southern Levant

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The Levant, forming an inter-continental land bridge, is pivotal for understanding *Homo sapiens*' dispersal from Africa and their interactions with Eurasian archaic *Homo* populations. The paleoanthropological record of the Middle Paleolithic (MP; 250–50 ka) suggests

the region was inhabited by at least two distinct hominin populations—Neanderthals and *Homo sapiens*—but linking these populations to specific lithic technological behaviors has proven challenging, particularly in the cases of the Middle and Late MP that exhibit high variability. By contrast, the Early MP is often viewed as being more homogenous, characterized by a relatively stable lithic tradition over approximately 100,000 years. This apparent stability contrasts sharply with the Middle MP, frequently interpreted as signaling new hominin migration waves into the Levant. We challenge this assumption by reexamining the Early MP of Tabun Cave's Layer D, based on Jelinek's excavation, dated to 250–200/190 ka. Jelinek well identified the variable nature of Layer D, dividing its 3-meter sequence into eight units (IX–II) and 43 layers (27–69). However, subsequent research has largely focused on the very early Unit IX, the best-preserved segment, while other units have been neglected, primarily due to the presence of erosional channels. Our analysis excluded heavily eroded Units III–IV and VI and focuses on the remaining units to trace temporal changes. The results reveal a gradual decline in blade production and retouched points, defining features of the "Tabun D" phase, alongside fluctuations in core technology, reduction sequence segmentation, and flint taphonomy. Micromorphological evidence further highlights variation in depositional environments, emphasizing gradual transitions rather than abrupt shifts. These findings demonstrate a clear, gradual transition from the Early to the Middle MP, prompting us to question whether the character of the lithic technologies in the Middle MP Levant should reliably be interpreted as evidence of hominin migration.

Reconstructing Herbivore Diet and Rainfall Seasonality Using Dental Microwear: Implications for Stone Age Foragers on the Southern Cape, South Africa

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Southern Africa's rainfall zones (Winter, Aseasonal, Summer) shape variations in key resources for foragers (e.g., vegetation, herbivores), therefore impacting mobility. A large body of research has proposed important changes in the temperate and tropical systems that influence southern Africa's climate. Still, the extent of these impacts on vegetation, herbivores, and human mobility remains unresolved. This study uses dental microwear texture analysis (DMTA) to reconstruct herbivore diets from the Late Pleistocene and early Holocene at Boomplaas Cave and Nelson Bay Cave on the southern Cape. We also develop a new method for estimating the season of death in modern and fossil herbivores. By matching DMTA data from modern herbivores with museum specimen collection dates and locations, we demonstrate seasonal dietary shifts in species such as springbok (*Antidorcas marsupialis*), impala (*Aepyceros melampus*), and blue wildebeest (*Connochaetes taurinus*). Generalized linear models of DMTA variables successfully predict monthly precipitation, reflecting increased grass consumption during wetter months for multiple species, including *Damaliscus pygargus, Antidorcas marsupialis,* and *Oreotragus oreotragus.* This method is promising for the development of a site occupation seasonality proxy. Additionally, molars of fossil herbivores (n=15) from Boomplaas and Nelson Bay Cave, including alcelaphins (*Connochaetes/Alcelaphus),* reedbuck (*Redunca* sp.), blue antelope (*Hippotragus leucophaeus),* African buffalo (*Syncerus caffer),* the extinct African long-horned buffalo (*Syncerus antiquus),* and an unnamed caprine were analyzed with DMTA. When possible, specimens were matched with stable carbon and oxygen isotopes to reconstruct diet using stable carbon and oxygen isotopes and DMTA. We find that the caprine is a grazer, which matches previous interpretations based on tooth morphology. However, other grazers, including alcelaphins and reedbuck, consume less grass than their extant counterparts. These findings reveal critical links between rainfall seasonality and herbivore dietary changes, which has implications for understanding forager mobility and hunting behaviors in the Late Pleistocene and early Holocene.

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New Late Pleistocene Records of Hunter-Gatherer Behavior and Environments in the Kasitu Valley of Northern Malawi

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The Zambezian open woodland belt of southern-central Africa has rich Middle and Later Stone Age records that have received little research relative to adjacent regions. Stratified rock shelter sites with organic preservation and deposits extending into the Pleistocene are especially rare, which hinders efforts to understand the local evolution of forager lifeways and their relationships to better-studied parts of Africa. New work in the Kasitu Valley of northern Malawi has involved the detailed excavation of five rock shelter sites with

good organic preservation. Two of these (Hora 1 and Mazinga 1) have deposits extending into the Pleistocene (>21 thousand years ago [ka] and >37 ka, respectively), and all have yielded large assemblages of animal bone, shell, lithics, ornaments, and other evidence of human occupation. These assemblages show changes in socio-symbolic behavior, technology, and subsistence that are broadly synchronous with a shift from more arid conditions during the Last Glacial Maximum to a mesic Terminal Pleistocene and Holocene. Faunal communities that prefer open habitat (e.g., ostriches and large grazing ungulates) largely gave way to smaller-bodied taxa more common in closed habitats, and faunal assemblages show increased exploitation of slow-moving prey such as giant land snails and tortoises. This transition is also reflected in a shift from the use of ostrich eggshell in bead-making to the earliest recorded use of land snail shells in Africa as raw materials for beads, directly dated at ~9.5 ka. The quartz-based stone tool assemblages show high levels of retouch, and the bone tool assemblages are also highly variable. This shows potential for the regional record to track changes in technological systems at finer spatial and temporal scales than has previously been reported. These new data give unprecedented insight into the relationships between Pleistocene paleoenvironments and human behavior in an important, but understudied part of Africa.

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The Late Glacial Record of Munyama Cave (Uganda)

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Africa's Lake Victoria Nyanza today supports the continent's largest freshwater lake, lies at the intersection of several biomes, and supports some of Africa's densest human settlements. There is a well-documented expansion and contraction of the lake throughout the Quaternary. However, the sparse regional archaeological record makes it difficult to understand the shift between the highly mobile Middle Stone Age foragers present when the area was a Serengeti-like grassland and Later Stone Age (LSA) occupants who focused longer term occupations on the lakeshore, relied on aquatic resources, and used early (Kansyore) ceramics. Munyama Cave (Uganda) is located on Buvuma Island immediately south of the outlet of the Victoria Nile; its sedimentary sequence spans the lake's last drying up and refilling from ~17–10 ka. It is one of the only Late Glacial sites in eastern Africa and serves to better connect MSA and Kansyore sites as the oldest LSA site in the in the Lake Victoria Nyanza region. Munyama Cave was excavated in 1968. Radiocarbon dates from the site historically helped establish the pre-Holocene antiquity of LSA sites, but other publication of other information was limited. We have begun reassessing the site's artifact and archival collections housed at the Royal Museum for Central Africa in Tervuren, Belgium. We have focused on: 1) the production and use of quartz backed microliths, 2) the substantial number of large stone tools transported to the site that were modified by percussion and grinding, and 3) the site's rich collection of anthropogenically modified 'ochre.' Discussions of these kinds of artifacts is often unnecessarily restricted to discussions of behavioral modernity. Instead, we use the Munyama Cave collection to document how communities in the Pleistocene employed these social and subsistence technologies in their daily lives in a way few other sites from this region can.

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Silcrete Use and Heat Treatment in the Middle Stone Age at Nelson Bay Cave, South Africa

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The heat treatment of lithic raw materials to modify their physical properties was a major technological innovation of the Middle Stone Age (MSA) and was present by at least ~130 ka in southern Africa. Most research on the heat treatment of silcrete in MSA lithic technology has come from sites in western South Africa. Less data is available about the context in which silcrete was acquired and modified along the southern coast, raising questions regarding how widespread the heat treatment of silcrete was in the MSA. This paper examines how silcrete was used at Nelson Bay Cave, South Africa, and the role of heat treatment in MSA technology at the site. Silcrete was a minor component of Early MSA lithic technology but makes a comparatively high contribution to the assemblage in the earliest Howiesons Poort layers at the site. Frequencies of silcrete use decrease in the later Howiesons Poort. The application of heat treatment remains relatively consistent, despite variation in the contribution of silcrete to the lithic assemblage. Results from Nelson Bay Cave support data from other sites in southern Africa indicating the widespread use of heat treatment in the Early MSA with little change in frequency through the Howiesons Poort.

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The Context of Butchery Across Cultures: Analysis of Overlaps Between Evidence and Preservation

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Currently, the scientific community has limited ways in which to identify butchery sites. The identification of these sites relies on correctly identifying individual markings on fossils found in the field. The study I have conducted seeks to identify the overlaps between bones that are most likely to show butchery markings, and bones that preserve well in the fossil record. Over the course of a year, I attended a series of butcheries in Koobi Fora, Kenya, working with local tribes to learn about methods and damage patterns. After watching the butcheries, we collected and cleaned all of the bones and identified each marking. This was followed by approximately 25 interviews, observations, and surveys with hunters and butchers in both the commercial and private sectors in the northeast United States to further observe techniques and patterns of damage. After identifying the sets of bones that show the most damage across all butcheries I observed, I took these data and compared them with data on what bones or bone sections would likely be well preserved in the location where I do my field work (East Turkana, Kenya), but this can also be applied to similar landscapes. The goal for this study was to identify this specific overlapping group in order to allow for more efficiency and faster identification of butchery sites and fossils during field work, allowing for further development into the study of butchery and its relationship to hominin evolution. While there is further work to be done for this study, currently I believe that this overlap consists mostly of long bones, the pelvic bones, and the base of the skull when available, but the data also detail where on these bones the damage is likely to be found.

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Environmental Change and Forager Land-Use in the Later Stone Age of Taforalt and Rhafas Caves, Morocco, as Inferred from Carbon Isotopes in Ungulate Tooth Enamel

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Later Stone Age (Iberomaurusian) hunter-gatherer groups in northwestern Africa appear to have experienced a major reorganization of land-use strategies and settlement dynamics around 15–13 cal ka BP, which broadly corresponds to the globally recognized Greenland Interstadial 1 (Bølling-Allerød) climate interval. However, our understanding of the local impacts of this interval on environments in Morocco is incomplete, as is our understanding of the strength of the relationship, if any, between paleoenvironmental change and human behavior in the Moroccan Later Stone Age. This study reconstructs environmental change during the Later Stone Age at the archaeological cave sites of Taforalt and Rhafas (northeastern Morocco), using stable isotopes of carbon in ungulate tooth enamel. Results are consistent with an expansion in local tree cover during Greenland Interstadial 1. This environmental shift is associated with changes in forager land-use behaviors, which at Taforalt included the exploitation of storable oak and pine-derived plant foods and greater intensity of site occupation. It is proposed that high local productivity of nut-bearing trees, potentially paired with regional increases in human population densities, contributed to greater intensity of occupations in northeastern Morocco during Greenland Interstadial 1.

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A Malthusian-Like Demographic Cycle at Natufian el-Wad, Mount Carmel, Israel

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Tracking humans' enduring effects on their environment is a central problem in human evolution. It is increasingly acknowledged that some intensive human settlements at the end of the Pleistocene strongly affected their surroundings in myriad ways, before any reliance on food production. This included intensified subsistence practices that could have depressed game populations, niche-constructing activities that altered the abundances of animal and plant taxa, and synanthropic relations whereby certain taxa benefited from the refuse or shelter provided by the habitation. The intertwined nature of these effects and their equivocal archaeological signals require a detailed, high-resolution and multi-proxy record to tease out. Here, we present a case study from one of the earliest hunter-

gatherer "built environments," the Early Natufian sequence of el-Wad Terrace, Mount Carmel, Israel (Yeshurun et al. 2025). A Bayesian age model showed that the record covers ca. 1,500 years at the most (14.8–13.2 ka), and likely just a few centuries. It includes an initial phase with little architecture, followed by an intensive architectural phase with ten stratified building levels, in turn capped by more ephemeral habitation levels. The sequence ends with even more ephemeral-looking Late Natufian deposits (ca. 13.2–12 ka). Using the rich zooarchaeological samples from each stage, and controlling the environmental parameters by independent proxies (plant carbon isotopes and microvertebrate accumulations), we test how hunting patterns changed with the mode of occupation, revealing the human response to the impact that a growing sedentary habitation had on the site's environment. Since our sequence's duration is comparable to ethnographically known demographic cycles, we suggest that these developments correspond to a Malthusian cycle, whereas gradual demographic growth in this early sedentary hamlet eventually led to an overpopulation crisis, which was mediated first by adjusting the subsistence patterns, and later entailed the partial abandonment of the site and settlement reorganization.

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Behavioral Uniformity Across *Homo* Groups in the Levantine Mid-Middle Paleolithic (ca. 130–80 ka): New Evidence from Tinshemet Cave, Israel

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The Levantine mid-Middle Paleolithic (mid-MP; 130–80 ka) is remarkable for its exceptional evidence of human morphological diversity, with contemporaneous fossils of *Homo sapiens* and Neanderthal-like hominins. The morphological diversity of the Levantine MP hominins became a source for heated debate regarding their taxonomic identity and the possibility of inter-population interactions in the region. How this morphological diversity is reflected in the cultural and behavioral records also remains a matter of debate. Coexistence with no interactions, alternating occupations, brief episodes of engagement followed by extinction, and inter-population interactions were suggested as scenarios to explain this record. The interactions' scenario is supported by the hybrid-like features of the Qafzeh and Skhul hominins, as well as the recent study based on the lithic technological behavior of the Nesher Ramla hominins, which suggests cultural diffusion and interaction across *Homo* populations. During the last decade, several important discoveries that support the inter-population interactions' hypothesis were made in the Levantine MP. Here we report on Tinshemet Cave, Israel, which yielded articulated *Homo* remains in association with rich assemblages of ochre, fauna, and stone tools dated to 110–100 ka. Viewed from the perspective of other key regional sites of this period, such as Qafzeh, Skhul, and Tabun caves, and Nesher Ramla, our findings indicate consolidation of a uniform behavioral set in the Levantine mid-MP, consisting of similar lithic technology, an increased reliance on large-game hunting, and a range of socially elaborated behaviors comprising intentional human burial and the use of ochre. The Levantine mid-MP exhibits behavioral characteristics that allow defining it as a unified cultural and behavioral entity and distinguish it from the preceding early MP and the following late MP. We suggest that the development of the mid-MP behavioral uniformity is due to intensified inter-population interactions and admixture between *Homo* groups ca. 130–80 ka.

Isotopic Evidence Speaks to Neanderthal Behavioral Resilience in the Southern Levant

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In the archaeological record, the causal relationship between climate shifts and behavioral patterns, visible or implicit, can be hard to disentangle. This is due partly to discrepancies in the chronological resolution of the two records, but also to difficulty in extrapolating site-centered environmental responses to regionally recorded climate shifts. This issue is particularly salient in the Levantine Middle Paleolithic, where the role of climate in hominin population overturns has long been debated. This paper presents the results of an isotopic analysis on plant waxes and tooth enamel recovered from the late Middle Paleolithic site of Amud Cave, Israel. A paired study of these archaeological proxies provides insights into the environmental change experienced locally during the occupation of the cave, while tracing concomitant changes in behavior. Our data suggest that during a period of decreased precipitation, the Neanderthal inhabitants of Amud Cave adjusted to local-scale environmental changes by shifting the altitude and direction of hunting ranges of gazelle and fallow deer, which remained the most abundant prey species throughout the occupation. Our results suggest that the site's inhabitants flexibly adjusted their hunting behaviors while conservatively maintaining both occupation seasonality and prey preferences. These results bear implications for discussions of Neanderthal ecological resilience in the southern Levant.