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(this is not the published version [coming in May 2019]  
and has been only lightly copy-edited)**

**Alemseged et al.**

**New hominin remains from Mille-Logya, Afar, Ethiopia and their implication for the origin of *Homo***

The Mille-Logya site is located in the Afar depression of Ethiopia, a paleoanthropological hotspot. The region has produced a vast amount of paleontological and archeological evidence for our understanding of the biological and cultural evolution of the hominin clade spanning the past 6 million years. Yet, as is the case in many places, the time interval between 3 and 2.5 Ma is poorly sampled in this otherwise prolific region. The Mille-Logya Project (MLP) area, which is located north of the Ledi-Geraru and east of Woraso-Mille research areas, contains sediments representing this crucial interval and has yielded rich faunal assemblages with important implications for environmental change in the sedimentary basin (Alemseged et al. 2016). It has also yielded hominin remains, albeit fragmentary, that will shed some light on hominin evolution in the 3 to 2.5 Ma interval. To date, our team has recovered four hominin remains including a diagnostic and complete upper second molar crown (MLP-1549), a calvarial fragment (MLP-1469) and right and left proximal ulnae (MLP-1617 & MLP-786), from different individuals. Further comparative analysis is underway to assess the taxonomic affinities of the cranial and postcranial fragments. The molar, has a generalized occlusal morphology and the buccolingual and mesiodistal dimensions fall within the known ranges for both early *Homo*, as represented by A.L. 666-1 from the younger horizons at Hadar, and *A. afarensis*. The occlusal surface, which is dominated by the two mesial cusps is rhomboidal with the longest axis running from the distolingual to mesiobuccal corners. Based on size and combination of mainly occlusal features, we attribute it to *Homo* sp. This molar thus represents one of the oldest specimens from this genus and expands the early *Homo* sample from the Afar, which currently includes only LD 350-1 from Ledi Geraru at 2.8 Ma and A.L. 666-1 from Hadar at 2.33 Ma.

**Almeida-Warren et al.**

**Landscaping chimpanzee and early hominin tool-use and resource exploitation — an ecological approach**

Ecology plays an important role in the emergence and maintenance of technological traditions in non-human primates, and shapes their tool-using behaviours (Koops et al. 2013; 2014; Carvalho et al. 2011, 2007; Rolian & Carvalho 2017). For example, raw material availability and proximity to water, influence site location and re-use, as well as frequency and distance of tool transport in chimpanzee nut-cracking (Carvalho et al. 2011, 2008). Such features may have also determined early hominin resource exploitation strategies and the distribution of archaeological assemblages, particularly before the emergence of more permanent “home bases” (e.g. Isaac 1981; Rose & Marshall 1996; Sept 2011). However, due to the sparsity of the earliest records and the absence of comparative frameworks, few studies have successfully tested these hypotheses. Our closest living relative, the chimpanzee, is a universal tool-user and provides key insights into the behaviour of our ancestors. Chimpanzee tool-activity areas bear similarities to low-density assemblages of early hominins, probably due to similar forage-on-the-go strategies (Carvalho & McGrew 2012; Thompson et al. in press, 2019). This provides a unique window for testing the mechanisms driving accumulation patterns across the landscape, using extant and extinct species. We develop the first standardized method of data collection for modern chimpanzee and early hominin sites and investigate which ecological variables drive the selection and re-use of nut-cracking locations by the chimpanzees of Bossou (Guinea). First results suggest that, after nut tree availability, access to raw materials and predictable resources (e.g. fruiting trees), are the main parameters explaining variability in nut-cracking assemblages, while proximity to sleeping sites is non-significant (random forest model: ntree = 500, nper = 999; variance explained = 26.33%;  $p < 0.05$ ). Ongoing comparisons with data from Koobi Fora (Kenya), will further test key models of landscape-use and provide a clearer picture of early hominin resource exploitation.

## **Ambrose and Brooks**

### **Revised chronology and environment of modern humans at Qafzeh based on ostrich eggshell stable isotopes and amino acid racemization**

Qafzeh Cave Terrace levels XVII-XXIV contain burials of 25 anatomically modern humans and, with Skhul, provide the earliest secure evidence for modern humans outside of Africa during Marine Isotope Stage (MIS) 5, 74-128 thousand years ago (ka). Thermoluminescence dates average  $92 \pm 5$  ka. Most publications cite the 92 ka date, which places occupation during cool, humid MIS-5b. Electron spin resonance dates range from  $96 \pm 13$  to  $120 \pm 8$  ka (Grün et al. 2005) while amino acid racemization results on ostrich eggshell (OES) show a steady increase in D-alloisoleucine/isoleucine values with depth from Levels XVII to XXI, suggesting that occupation began as early as MIS-5e, 120-128 ka and continued over a significant period. Seasonal variation in tooth enamel carbon and oxygen isotopes (high  $\delta^{13}\text{C}$  and low  $\delta^{18}\text{O}$ ) from level XXI (Hallin et al. 2012) show that goats fed on  $\text{C}_4$  plants in a summer rainfall climatic regime. Stalagmite oxygen and carbon isotopes nearby from Soreq and Pequin caves also show high  $\delta^{13}\text{C}$  and low  $\delta^{18}\text{O}$ , during MIS-5e, 120-128 ka (Bar-Matthews et al. 2003). Qafzeh level XXI thus likely dates to at least 120 ka. Carbon isotope analysis of OES from levels XIV-XXII show the highest  $\delta^{13}\text{C}$  values ( $-8.5\%$ ) in level XXI, reflecting diets with 25-30%  $\text{C}_4$  plants. Palearctic fauna are absent from layers XIV-XXIV at Qafzeh, and Tchernov and Rabinovich (1995) propose that this Afro-Arabian fauna reflects a tropical savanna environment. If Qafzeh was occupied during MIS-5e, then modern humans likely left Africa across a green Sahara and Sinai, during the period of least ecological resistance. Expansion out of Africa before 120 ka, far predating the accepted molecular genetic date of 70 ka for the founding of Eurasian modern human lineages (Nielsen et al. 2017). This supports proposals that MIS-5 modern humans in the Levant represent a failed dispersal out of Africa.

## **Banks et al.**

### **Neanderthal ecological dynamics north of the Pyrenees and west of the Jura/Alps between MIS 5a and MIS 4.**

The use of culture as a means of adaptation allows human populations to adjust quickly to changes in the environmental frameworks within which they operate. Therefore, an important variable to take into account when examining past hunter-gatherer cultural adaptations, especially across periods marked by pronounced climatic variability, is the ecological niche (i.e., the suite of environmental conditions) exploited by an archaeological population. Recent applications of ecological niche modeling methods to examinations of the archaeological record have demonstrated that certain anatomically modern human (AMH) regional cultural trajectories were marked by an expansion of the exploited ecological niche across periods of significant environmental reorganization (Banks et al., 2013; d'Errico et al., 2017). Rarely have such methods been applied to the Neanderthal archaeological record (Banks et al., 2008; Benito et al., 2017), and the relationships between Neanderthal cultural adaptive variability and ecological niche dynamics in the context of late Pleistocene climatic variability remains largely unexplored. Such investigations are extremely pertinent in light of our growing realization that Neanderthal technologies and cultural behaviors were highly varied, complex, and on par with those observed for early modern human populations. This study examines the Neanderthal archaeological record in present-day France and associated with MIS 5a and MIS 4 (ca. 80–60k cal BP) via ecological niche modeling methods and high-resolution paleoclimatic and vegetation simulations for the period in question. Results demonstrate a significant shift in the Neanderthal ecological niche between the two isotope stages, while niche breadth remains constant. This niche signature differs from those documented for AMH populations and discussions will focus on the Neanderthal cultural behaviors behind this particular culture-environment relationship.

## **Beasley et al.**

### **Cooking, Putrefied Meat, Fish: What $\delta^{15}\text{N}$ values might indicate about Upper Paleolithic Diet**

In 2017, Royer et al. stated in their abstract that  $\delta^{15}\text{N}$  values for cooked meat and fish could change up to 3.5‰, however the data indicated that cooked meat (boiled, fried, or roasted) did not increase in  $\delta^{15}\text{N}$  rather the fish that were boiled or roasted showed a significant increase in  $\Delta^{15}\text{N}$ . Additionally in 2017, Speth proposed that the consumption of putrid meat and fish might be a dietary

item that is underexplored in the Upper Paleolithic food menu. We explore the  $\Delta^{15}\text{N}$  observed in muscle tissue decomposing during winter of mammals averaging 176 pounds. During the first 40 days when daily temperatures average 9.3 °C, no significant difference is observed from the starting  $\delta^{15}\text{N}$  value (mean  $\Delta^{15}\text{N} = 0.1\text{‰}$ ). However, from day 41-76 (when identifiable muscle tissue was still present), there is a significant increase in  $\Delta^{15}\text{N}$  with an average increase of 1.7‰ despite no significant change in the daily temperature average or max daily temperature, 10.0 and 25.6 °C, respectively from the first 40 days sampled. Therefore, in moderately cold weather, mammal muscle tissue consumed within the first 40 days after death, would not increase  $\delta^{15}\text{N}$  values of the consumer. In colder weather, it is assumed that during early decomposition the period of stasis in  $\delta^{15}\text{N}$  values would exceed 40 days. Together this data leads to an interpretation that Paleolithic hominins (Neanderthals and modern humans) might consume cooked and putrefied meat, but neither would contribute to high  $\delta^{15}\text{N}$  values, while cooked fish could be responsible for higher  $\delta^{15}\text{N}$  values.

**Belmaker et al.**

## **Modern human adaptability to hot and dry environments: the faunal evidence from Tor Hamar F, Southern Jordan.**

The Upper Paleolithic (UP) in the Levant is a critical time period to understand ecological adaptation of modern humans. Faunal studies aimed at uncovering subsistence patterns and mode of prey acquisition are key in such adaptation. The UP of the Levant often suffers poor bone preservation, primarily in the arid regions. Tor Hamar layer F, Southern Jordan is a late Pleistocene site situated in Southern Jordan (dated to 31–35 ka by OSL). The large faunal assemblage recovered from the site stands out among other UP sites in the arid regions and allows for an in depth taphonomic studies. The site was excavated in the 1980s and recently from 2016 onward. The faunal analysis from the early excavations recorded few damage modifications, with body part distribution explained as a result of post-depositional effects. During the new excavations additional material has been retrieved from the site and provides an opportunity to reevaluate previous conclusions. This study presents the taphonomic study of faunal remains retrieved from Tor Hamar layer F from both new and older excavations and analyzes them in comparison to other Upper Paleolithic sites and their reconstructed paleoecology. Taphonomic variables were measured on fragments >2cm following published procedures. Results suggest that fracture type, angle, surface and profile are all indicative of intense processing of limb bones often associated with marrow and grease extraction. The level of intensification is higher than that from penecontemporaneous sites in the Mediterranean region but not as high as those dated to the late Upper Paleolithic and Epipaleolithic and more akin to those in dryer environments such as the Zagros, consistent with the hot and dry environmental reconstruction of Tor Hamar F. These results point to the adaptability of modern humans and their flexibility to modify their subsistence patterns in different climates.

**Benedetti et al.**

## **Paleoclimate and site formation processes across the Middle and Upper Paleolithic at Lapa do Picareiro, Portugal**

The mountaintop cave site of Lapa do Picareiro contains one of the longest and most complete late Pleistocene sequences in Portugal, with more than 10 m of stratified sediment in 37 stratigraphic levels dating to roughly 9-75 ka. Archaeological excavations here since the 1990s have recovered Middle Paleolithic (Mousterian) and Upper Paleolithic (Aurignacian, Gravettian, Solutrean, Magdalenian) lithic assemblages, abundant fauna, cut-marked bones, and ash/charcoal in hearths. Geoarchaeological studies at Picareiro have focused on site formation processes, sedimentation rates, and paleoclimate correlations. Most of the sedimentary fill is limestone éboulis derived from spalling of small clasts, and fine sediment from small-scale debris flows and infiltration through bedrock fractures. Sedimentation rates over the radiocarbon-dated section (9-45 ka) varied between 0.1-0.3 mm/yr, with an acceleration after about 25 ka. Bone preservation in the cave is good and disturbance by bioturbation, dissolution, or erosional processes appears to be limited. Rhythmic bedding in the central part of the cave, where clast-supported coarse éboulis beds alternate with muddy finer éboulis beds, suggests a connection with late Pleistocene climate fluctuations. The most promising paleoclimate proxies are magnetic susceptibility and éboulis clast size which match Greenland ice core and deep sea sediment records closely back to at least 40 ka. The cold-arid Heinrich stadials (H1-H4) are represented by coarse clast beds with little fine sediment and magnetic susceptibility minima, while warmer interstadials correspond with muddy beds and sharp peaks in magnetic susceptibility. Overall the sequence reflects a karst system subject to intense frost weathering during cold phases, and increased wetness with enhanced mud transport and faunal activity during warm phases. This work complements ongoing

archaeological excavation at the site and confirms that the sequence has the proper age, resolution, and preservation to inform on Late Pleistocene cultural and climatic transitions.

## **Beyin and Ryano**

### **Hierarchical centripetal core technology in the Kilwa basin, coastal Tanzania: Implications for hominin movements between interior and coastal East Africa**

There exists a major gap in our knowledge of the extent to which hominin biogeography included the eastern African coastal landscapes along the Indian Ocean as most previous Paleolithic studies in the region have remained focused on the hinterlands, mainly in the vicinity of the Rift Valley. A recent archaeological reconnaissance in the Kilwa basin (coastal Tanzania) has recorded sites featuring hierarchical centripetal core technology. Among the defining characteristics of this occurrence is the hierarchical centripetal system of core exploitation, whereby the core is prepared in such a way that one surface serves as a flake release (principal exploitation surface) and the other as a striking platform [1,2]. This method allows predetermination of the size and shape of the resulting flakes, and such a concept is believed to have entailed an advanced cognitive template [2]. Although the centripetal strategy of core exploitation is often assumed to be a hallmark of the Middle Stone Age/Middle Paleolithic technocomplex[3] (associated with late Middle and Later Pleistocene hominins), de la Torre and colleagues [2] have recorded an Oldowan Industry in the ST Site Complex of Peninj (Lake Natron region, Tanzania) characterized by this method. Dated to 1.6–1.4 Ma, the Peninj occurrence signifies the centripetal strategy had a much older temporal span in East Africa, and that our finds from the Kilwa basin (which have not been radiometrically dated yet) may represent part of a regional technocomplex practiced by Pleistocene hominins that moved between the interior and coastal habitats of East Africa. In this poster presentation, we will describe the hierarchical centripetal schemes that characterize the Kilwa occurrence and the broader implications of the evidence. The discovery of Stone Age sites from the Kilwa basin provides a promising starting-point for placing the East African coast in the spotlight of human evolutionary research.

## **Brandt et al.**

### **Social Memory and Persistence of Lithic Technological Strategies in Late Pleistocene Eastern Africa: Implications for Interpreting Hunter-Gatherer Lithic Technological Variability In and Out of Africa**

Recent excavations at Late Pleistocene sites in Eastern Africa have provided surprising evidence for the continued presence in very low frequencies (1-8%) of certain lithic technologies and tool types that persevere for thousands or tens of thousands of years after their main period of use, into terminal Pleistocene or even Holocene times. The sites' archaeological sequences reveal two major patterns of technological perseverance: 1) continuous persistence of specific technological strategies in very low frequencies; and/or 2) persistent but discontinuous presence of technologies in very low frequencies that show repeated cycles of disappearance followed by reappearance. Archaeological discussions of these phenomena fall short of providing explanations: Suggestions that consistently low frequencies reflect "unpopularity" as depicted in the tails of classic battleship curves do not explain the persistence of an unpopular technology; and invocations of diffusion, migration and/or convergent evolution to explain why similar technologies come and go are typically so generalized as to lack explanatory power for any specific case. This paper develops an explanatory framework wherein the interplay of mental and material activities in Levallois reduction are considered within the broader context of the creation and reproduction of social memory. In this light, goal-oriented, highly skilled and structured technologies such as Levallois multiple reduction strategies are carefully maintained and stored through time, regardless of environmental or social changes, until they are needed for whatever purpose, or forgotten. We discuss how such a social memory model can be tested, and its possible implications for constructing (or deconstructing) cultural historical frameworks and technological "transitions". We conclude by examining its potential to help interpret hunter-gatherer activities, evaluate purported links between specific lithic technologies vs. hominin species, and gauge intra-and inter-regional technological and typological variability as hunter-gatherers dispersed across and out of Africa (and back) into new worlds with similar or radically different environments.

**Brittingham et al.**

## **Organic Molecular Record of Fire from Lusakert Cave, Armenia and its Implications for Fire Use in the Middle Paleolithic**

A number of different direct and indirect proxies are used to identify and quantify fire at archaeological sites. Here, we present a record of the abundance of polycyclic aromatic hydrocarbons (PAHs), organic compounds that are produced during the combustion of organic material, and are preserved well on deep time scales. We extracted these molecules from sediment samples in each stratigraphic unit at Lusakert Cave, a Middle Paleolithic site in the Hrazdan Gorge, Armenia to determine the behavioral and climatic controls on hominin fire use in the Middle Paleolithic. We find no correlation between the frequency of light PAHs (PAHs with 3 or 4 aromatic rings), which are shown to disperse widely from the source of fire and can serve as a proxy for wildfires, and heavy PAHs (PAHs with 5 or 6 aromatic rings), which are abundant proximal to the source of the fire and can be a proxy for anthropogenic fire in this cave setting. Instead, we find heavy PAHs correlate with artifact density at the site. Given that anthropogenic fire frequency correlates with occupation intensity rather than wildfire frequency, we argue that MP hominins were able to create fire independent from the fire available from natural sources on the landscape. We also analyzed the  $\delta D$  and  $\delta^{13}C$  values of plant wax biomarkers (n-alkanes) to measure vegetation and hydrological changes at the site during its occupation, showing this behavior occurred during periods of climate variability. This coupled record of climate and fire from sediments containing archaeological material gives insight into the ability of Middle Palaeolithic hominins to control fire through changing ecological regimes.

**Bruxelles et al.**

## **A multiscale stratigraphic investigation of the context of StW 573 Little Foot and Member 2, Sterkfontein Caves, South Africa.**

Discovered in the Member 2 deposit in the Silberberg Grotto, StW 573 represents the most complete *Australopithecus* skeleton yet found. Because of its importance to the fossil hominin record, the geological age of Little Foot has been the subject of significant debate. Two main hypotheses have been proposed regarding the formation and age of Member 2 and by association StW 573. The first proposes that Member 2 started to accumulate at around 2.8 million years ago and that the unit is isolated to the Silberberg Grotto - the underlying chambers and passages forming later. The second proposes that Member 2 started accumulating before 3.67 million years ago and that the deposit extends into the Milner Hall and close to the base of the cave system. Recently a third alternative hypothesis questioning the association of StW 573 to Member 2 sediments proposed a two-stage burial scenario in which sediments associated with StW 573 represent a secondary and mixed-age deposit reworked from a higher cave. The stratigraphic and sedimentological implications of these hypotheses are tested here through the application of a multiscale investigation of Member 2. The complete infilling sequence of Member 2 is described and depositional units are tracked across all exposures of the deposit in the Silberberg Grotto and into the Milner Hall. Sediments are generally stratified and conformably deposited in a sequence of silty sands eroded from well-developed lateritic soils on the landscape surface. Voids, clasts and bioclasts are organized consistently across and through Member 2 according to the underlying deposit geometry, indicating a gradual deposition. The stratigraphy and sedimentology of Member 2 supports a simple single-stage accumulation process through which Member 2 partially fills the Silberberg Grotto and extends into the deeper chambers and passages of the Sterkfontein Caves.

**Carvalho et al.**

## **A stable isotopes analysis of ungulate remains from Lapa do Picareiro: an assessment of refugia concepts during the Middle Paleolithic and transition to Upper Paleolithic**

Neanderthals and anatomically modern humans (AMH) adapted to a series of environmental changes during the Late Pleistocene and may have sought refugia in the southern reaches of Europe during periods of unfavorable climate in response to environmental degradation. Explanatory models such as the Ebro Frontier Model (1) propose that Neanderthals were adapted to woodland

environments while AMHs preferred open landscapes. This model suggests that Late Neanderthal survival in southern Iberia may have been the result of Neanderthals seeking refuge during the relatively mild conditions during MIS 3 on the peninsula. Heinrich Events, especially H4, on the other hand, may have created harsh climatic conditions that may have reduced Neanderthal populations below survival thresholds. Thus, reconstructions of paleoenvironmental conditions to which Neanderthals and AMHs were subjected are key to understanding whether both groups periodically sought refuge in Iberia. Here, we present a paleoenvironmental study using stable isotopes analysis of carbon and oxygen of red deer and ibex tooth enamel from Mousterian and Early Upper Paleolithic levels from Lapa do Picareiro (Portuguese Estremadura). These data are then compared to previous isotopic data recovered from red deer and rabbit tissues as well as other paleoclimate indicators from Picareiro to assess whether central Portugal acted as a refugia during periods of unfavorable climates.

**Coelho et al.**

## **Let the computers do the surveying: applying support vector machines on spectral data to identify new fossiliferous deposits in Koobi Fora, Kenya**

Many important findings in human evolution were discovered by accident. While luck still plays a major role in palaeontological surveying, attempts have been made to increase the likelihood of discovering new fossil sites using statistical approaches. Previous work required many examples of manually labelled landcover variables to train the model, such as grassland, wetland, scrubland, forest, roads, rivers, lakes, and fossiliferous deposits (e.g. Emerson & Anemone, 2012). However, most times, researchers will have precise GPS coordinates for already known fossil sites, but no efficient way of correctly labelling all the other negative classes. Using a subset of georeferenced fossils from the PaleoTurkana Database (Bobe & Carvalho, 2019) we implemented a one-class supervised classification algorithm that only requires data from the positive class. On a raster object of 2072 km<sup>2</sup> (resolution: 30x30m) containing 7 spectral bands of Landsat8 and a DEM, we trained one-class support vector machines to detect 1864 cells known to be fossiliferous. This is the first implementation of one-class classifiers for remote fossil detection in Africa. We defined the predictive class using a threshold value to reduce the total surveying area while increasing the likelihood of detecting fossiliferous deposits. With this optimal threshold we obtained a true positive rate (TPR) of 91.15% for all known georeferenced fossiliferous areas in Koobi Fora. Even when tested in a separated validation set (i.e. not used during model training) containing 478 fossiliferous cells, the TPR was 79.91%, as it correctly detected 382 of these cells in the grid. With an extremely high negative predictive value (>99.99% in both cases), this model is particularly good at telling palaeoanthropologists where they should not expend surveying effort, a desirable goal for cost-effective fieldwork. This useful information can be further enhanced by increasing the cut-off value of the predictive class to a higher degree of confidence.

**Coil et al.**

## **Comparisons of impact flakes derived from hyena and hammerstone long bone breakage**

The quantification and analysis of bone fragments from archaeological assemblages help zooarchaeologists understand the taphonomic processes involved in site formation. The presence of impact flakes, or bone flakes that exhibit features analogous to those found in knapped stone flakes, such as a platform, bulb of percussion, and hackle marks, are well documented in taphonomic literature and are generally understood to be a common byproduct of hammerstone breakage. Impact flakes are often used as supporting evidence for the interpretation of human created assemblages. Yet most archaeologists agree that carnivores are also capable of creating bone flakes and stress the paucity of taphonomic studies quantifying equifinality between carnivore and human created assemblages. Expanding our field's current knowledge of impact flake variability and equifinality increases the types of fragmentary bone that are useful in analysis. Here, we present quantitative data on bone flakes created by hyenas, and compare these data to an assemblage generated from experimental hammerstone breakage. We examine assemblage wide trends in flake frequencies, dimensional data (length, width, thickness), the presence/absence of flake features (platform, bulb of percussion, hackle marks, point of percussion), and ventral surface roughness (measured with a Nanovea White Light 3D Profilometer) in bone fragments created by each agent of breakage. Thus we address several questions: 1) Are impact flakes present in the hyena assemblages at the same frequency as in hammerstone broken assemblages? 2) Are each of the flake features found in equal frequencies and are flake dimensions and surface roughness similar regardless of breakage agent? 3) As notches created with

carnivore teeth have been characterized to be generally narrower and deeper than hammerstone created notches, do impact flakes from each respective assemblage reflect these dimensions? 4) Are our experimentally derived frequencies comparable to assemblages comprised of different taxa from published archaeological and experimental contexts?

**Collins et al.**

## **Late Pleistocene archaeology from Grassridge Rockshelter, South Africa, and implications for understanding Southern African behavioral diversity**

Grassridge Rockshelter sits in the interior grasslands of southern Africa, a chronically understudied region situated at an important bioclimatic nexus just north of the head waters of the Great Kei River, and just south of the culturally rich and well-described archaeological archives in the Drakensberg Mountains. Recent research focusing on the Late Pleistocene (~ 40,000 to 35,000 years ago) deposits from Grassridge demonstrates a novel configuration of cultural and technological behaviors, emphasizing the importance of the interior of southern Africa for understanding human behavioral diversity and social connectivity during this period. Here we summarize the results of this research, including a revised high-resolution chronology for the site's Late Pleistocene deposits, an interpretation of the site's formation processes and palaeoenvironmental context, a description of lithic technologies, and a description of the use of plants and ochre by the Late Pleistocene occupants at Grassridge. These results demonstrate both behavioral similarities and differences between the Late Pleistocene peoples at Grassridge and those at other similarly aged sites from different regions in southern Africa, and stress the importance of the interior for understanding the diversity of adaptive behaviors and social connections during this period.

**Cooper**

## **Setting the standard: differentiation of modern wood ash using infrared spectroscopy: archaeological applications to Paleolithic rock shelter, Crvena Stijena, Montenegro.**

Fourier Transform Infrared (FTIR) spectra of calcitic deposits at Middle Paleolithic rock shelter Crvena Stijena, Montenegro in tandem with Regev et. al's (2010) grinding curve procedure have helped differentiate geogenic and pyrogenic calcite deposits at level XXIV of the site. Trend lines for pyrogenic deposits are variable, however, which leads to the question: can we distinguish between wood-ash sources using the grinding curve procedure? Furthermore, how can these varying standards assist in the reconstruction of site formation processes? The idiosyncratic nature of cave and rock shelter sites can make their history, structure, and functions difficult to reconstruct. This is especially true when interpreting evidence for pyrotechnological activities, which has been subject to diagenetic processes. Hard and soft woods in the locality of Crvena Stijena have varying chemical signatures after being burned to ash. These modern ash samples may offer information on the chemical contribution to preservation or loss of archaeological materials while also shedding light on resource availability to Neanderthals in the Middle Paleolithic.

**Costa et al.**

## **Water sources and tool site distributions: hominins and chimpanzees compared**

As one of our closest living relatives and ubiquitous tool users, chimpanzees are useful models for hominin behavioural evolution. Chimpanzee habitats may mirror aspects of the forest and woodland habitats of earlier hominins. Early archaeological sites are frequently associated with fluvial and lacustrine depositional environments and these assemblages often reflect their environmental contexts (e.g. raw material availability). However, the relationship between landscape hydrological features and tool site selection is poorly understood. The presence of water confers benefits as ecological necessity and food source, and predictor of plant species

providing shade and shelter (Braun et al., 2010). While later hominins developed behaviors allowing them to cast off ecological tethers, earlier hominins appear bound by ecology, which closely reflects patterns at chimpanzee sites (Carvalho & McGrew 2012). We investigate ecological patterns of nut cracking sites at the wild chimpanzee locality of Bossou, Guinea, where tool density correlates with water, along with food and raw material source. Tool density increases as distance to water decreases ( $p < .01$ ). Recorded sites at Diecké, Guinea are under investigation and also proximate to water sources (Carvalho et al., 2007, 2008). We explore similar trends associated with surface indications of tool use in Pleistocene hominins in the Koobi Fora Formation, Kenya and their relationship to paleoenvironmental reconstructions of surrounding water systems. We explore patterns of tool use in sediments extending from 1.5 Ma to  $>2.2$  Ma, considering water availability estimates. Not all tool use behavior appears driven solely by the availability of stones. Water distribution on earlier hominin landscapes appears to have a similar impact as that seen in Bossou. We explore possible reasons underlying variation. Later hominin sites may become increasingly decoupled from water, due to behavioral and climatic shifts.

## Daegling

### Shear stress as a determinant of bone growth and morphology and its relevance to functional inference in the fossil record

Computational simulation has emerged as an effective tool for modeling evolutionary and/or developmental processes (e.g., Grove 2015). A major component of paleobiological reconstruction is establishing functional linkages between bone biomechanical properties and behavior. It is well-established that the mechanical environment during growth has substantial impact on adult skeletal morphology; consequently, modeling alternative hypotheses of how bone reacts to stress during ontogeny is worthwhile. Beam theory informs studies of fossils through consideration of normal stresses arising under bending loads. While this is valid for the analysis of long bones, it is arguable that for certain skeletal elements (e.g., mandible, femoral neck, olecranon process), shear stress is the more important consideration. This study examines how shear influences adult morphology, specifically with respect to proposed “adaptive algorithms” of bone growth. Recruiting existing data for bone strength, apposition rates and somatic growth, I simulated ontogenetic change in bone morphology as a mechanically-determined response to torsional shear stress from five different initial geometries (one symmetrical and four asymmetrical). Bone growth was simulated under distinct forms of stress stimuli: 1) local responses based on defined thresholds (“all or nothing” apposition) or tied linearly to stress magnitude, 2) global responses sensitive to average or maximum stress and 3) stress gradients (change in stress as a function of distance). These adaptive algorithms were evaluated in terms of strength and efficiency (i.e., convergence on an isostress condition). Local sensitivity to absolute and relative stress magnitude produces relatively strong and efficient bones. Other stress stimuli produce more irregular, but certainly functional, adult geometries. The implications for paleoanthropology are twofold: 1) adaptation to shear stress can produce asymmetric geometries resembling those explained under beam theory, and 2) different metabolic responses of bone to stress are as consequential as distinctive loading regimes for producing morphological variation.

## Davis et al.

### Seasonality and Subsistence Strategies at SM1, a late Middle Stone Age Site in the lowlands of northwestern Ethiopia

SM1 is an open-air late Middle Stone Age site located along the Shinfa River in NW Ethiopia. Ongoing excavations have recovered thousands of lithics and faunal remains deposited over multiple seasons of occupation at a time when seasonality and aridity in the region were at least as extreme as today. Zooarchaeological and taphonomic analyses offer insight into site formation processes and human foraging behavior, and document diverse terrestrial vertebrates ( $n=4467$ ), fish ( $n=3114$ ), and mollusks ( $n=467$ ). Most specimens are very small, non-identifiable bone and tooth fragments. Bovids and birds are the most common terrestrial fauna (80% of NISP identified to taxon). Other taxa include wildcat/serval, warthog, monkey, hare, porcupine, gerbil, crocodile, lizard, snake, and frog, with only a handful of specimens larger than size class 2. Fish include multiple families of Siluriform catfish, as well as several cyprinid and cichlid genera. *Clarias* is the most abundant genus (56% of NISP), followed by *Synodontis* and *Bagrus* (12% and 9% of NISP). Taphonomic analyses document abundant evidence for human accumulation and modification of terrestrial fauna and fish, and moderate, but not necessarily insignificant, damage by non-human agents and processes. Results indicate that foraging behavior was seasonally structured, with a likely emphasis on fishing and aquatic foraging during the dry season. Studies of modern fish burials suggest that the prevalence of *Clarias*, *Synodontis*, and *Bagrus* may be due in part to preservational biases, but may also reflect natural taxonomic abundances and, to some extent, human foraging decisions. New data from additional MSA sites



in Ethiopia indicate that taphonomic signatures from SM1 are similar to other open-air sites and suggest caution when interpreting human behavior at open-air sites based on criteria derived largely from cave/rockshelter sites. Results provide a taphonomic baseline for future studies of open-air MSA sites in the Horn of Africa.

## **Du and Alemseged**

### **Temporal evidence shows *Australopithecus sediba* is unlikely to be the ancestor of *Homo***

Understanding the emergence of the genus *Homo* is a pressing problem in the study of human origins. This includes determining which species may have been ancestral to *Homo*. *Australopithecus sediba* has recently been proposed as a candidate for this title, so it is essential we critically evaluate this claim. Fossil specimens from *A. sediba* are currently only known from Malapa, South Africa, which is dated to 1.977 million years ago (Ma) (Pickering et al. 2011). These specimens postdate by 800,000 years the first appearance datum of *Homo*, which is dated to 2.8-2.75 Ma at Ledi-Geraru, Ethiopia (DiMaggio et al. 2015). Here, we construct a probability model, which serves as a null hypothesis test, to evaluate if *A. sediba* is ancestral to *Homo*. We quantify the probability of finding one *A. sediba* fossil horizon that postdates one early *Homo* fossil horizon (i.e., the observed data), assuming the former species is ancestral to the latter one (i.e., the null hypothesis). Results show that observing this chronological pattern is unlikely, perhaps as low as or lower than a 1% probability. We corroborate these results by searching the literature and finding that within pairs of purported hominin ancestor-descendant species, in only one case did the first-discovered fossil in the ancestor postdate that from the descendant. Together, these results suggest it is highly unlikely that *A. sediba* was ancestral to *Homo*. Hypothesized ancestor-descendant relationships must satisfy both temporal and morphological criteria (Paul 1992). We tested the first criterion here, and the second one has been tested elsewhere (Kimbel and Rak 2017). *A. sediba* fails both benchmarks, and the most viable ancestral candidate for the genus *Homo* remains *Australopithecus afarensis* both on morphological (Villmoare et al. 2015) and temporal grounds (Alemseged et al. 2018).

## **Egeland et al.**

### **BK East, an early Pleistocene site in Middle Bed II (Olduvai Gorge, Tanzania)**

Olduvai Gorge, Tanzania, remains one of the richest sources of information on human bio-behavioral evolution during the early Pleistocene. The site of BK, which appears along the south edge of the side gorge, preserves at ca. 1.2 million years ago some of the oldest evidence for systematic megafaunal butchery. Here, we report on the site of BK East, a fossiliferous deposit situated in Middle Bed II, stratigraphically just below, and about 100 meters east of, BK. Excavations between 2014 and 2018 have revealed a dense accumulation of well-preserved lithic and faunal material. Preliminary taphonomic, zooarchaeological, and lithic data indicate that early Pleistocene hominins transported and worked lithic material and butchered several mammals at the site. Our geological and paleoecological work reveals that the site formed in a fluvial setting, perhaps within a braided river system. Together, these data add to the growing body of knowledge regarding hominin adaptations in East Africa ca. 1.4 million years ago.

## **Fanuka**

### **Differential diagenesis as determined from infrared spectroscopy on faunal bones from Middle Paleolithic site El Salt, Spain**

Rabbit and hare (Leporidae) bones from the Middle Paleolithic archaeological site of El Salt were examined via potassium bromide absorbance Fourier-Transform infrared spectroscopy (KBr-FTIR). The crystallinities of the hydroxyapatite within the bones were recorded using both the infrared splitting factor (IRSF) and the full-width-half-height (FWHH) of the main phosphate peak. Carbonate and organic matter contents were also estimated by calculating ratios of peak heights. The bones from two separate and

prevailing archaeological facies within the site display differential signals of diagenesis, indicating that different geological or site formational processes are occurring or have occurred within the two facies.

## **Finestone et al.**

### **Raw material selection and transport at three Oldowan localities on the Homa Peninsula, Kenya**

Three Oldowan localities have been found on the Homa Peninsula, southwestern Kenya: Sare River (ca. 1.77 Ma), Kanjera South (ca. 2 Ma), and Nyayanga (ca. 2.6 Ma). Together these sites offer a snapshot into regional patterns in raw material selection and transport across time scales. Kanjera South (KJS) has been the most intensively studied, and previous research has documented the preferential selection of durable lithologies from non-local sources providing evidence for the earliest habitual transport of raw materials over long distances. At nearby localities Nyayanga and Sare River, hominins also preferred durable materials. Nyayanga hominins preferentially selected rhyolite (40.4% of assemblage), quartz (29.9%), and quartzite (27.2%). Trace element geochemistry obtained from X-ray fluorescence spectroscopy indicates that rhyolite and quartzite artifacts at Nyayanga came from the same primary sources as those previously identified for KJS. While some rhyolites may have been locally available to KJS and Nyayanga hominins, quartzite is not present on this part of the Peninsula. A 2018 survey of nine paleo-conglomerates confirmed that secondary drainages carried quartzite in low frequency (<2%) four kilometers from Nyayanga, but not within a four-kilometer radius. Thus, Nyayanga hominins were obtaining quartzite from several kilometers away, extending the record of habitual transport of non-local materials for flake production. Alternatively, Sare River hominins produced tools from locally available materials. All tools were made from lithologies present in the nearest paleo-conglomerate and the assemblage is dominated by quartz artifacts (84.8%) produced from abundant quartz pebbles (45.7% of paleo-conglomerate). Thus, toolmakers on the Homa Peninsula preferred durable raw materials, however, early toolmakers traveled surprisingly long distances to obtain them while later hominins utilized locally abundant lithologies.

## **Fisher et al.**

### **Coastal occupation and foraging during the Late Pleistocene and Early Holocene at Waterfall Bluff, eastern Pondoland, South Africa**

Fundamental to understanding human evolutionary adaptations and survival is developing predictions of the human behavioral response to ecological variability. The Late Pleistocene is notable for climatic and environmental changes as long-standing glacial patterns transformed into the contemporary interglacial Holocene. In South Africa, the climatic changes across this glacial/interglacial transition had major impacts on continental paleoenvironments with localized changes to plant, animal, and freshwater sources that hunter-gatherers relied on for survival. Many studies have explored the relationship between hunter-gatherer resource availability, land-use and foraging strategies, mobility, and technological organization, but few have studied these effects in persistent near-coastal contexts, and fewer still in a coastal context spanning a glacial / interglacial transition. Coastal zones, having both diverse and predictable foods, may have uniquely influenced hunter-gatherer risk responses during periods of climatic and environmental change. These places may have been sought out by hunter-gatherers for their resource stability that provided a buffer against the effects of climate and environmental change. Unfortunately, few records of coastal occupation in South Africa contain evidence dating to glacial periods. However, new excavations by the P5 Project at the site of Waterfall Bluff (A2SE-1) in South Africa's Eastern Cape Province have revealed stratified and well-preserved remains of coastal hunter-gatherer occupations dating to the Late Pleistocene and start of the Holocene, with key deposits spanning the Last Glacial Maximum. Here, we describe recent archaeological, sedimentological, paleoenvironmental, and geochronological research at the site and summarize upcoming research activities. Our multiproxy paleoenvironmental results show major climate and vegetation changes between the Holocene and the Late Pleistocene. The archaeological records also provide new insights into the coastal adaptations of hunter-gatherers during the glacial maxima and across the glacial/interglacial transition, providing a unique opportunity to study coastal hunter-gatherer behavioral adaptations across a glacial / interglacial transition.

**Florin et al.**

## **New Work at Ewass Oldupa and Engaji Nanyori (Beds I-IV, Olduvai Gorge, Tanzania)**

Olduvai Gorge situates two million years of evolutionary history (Leakey, 1971; Leakey and Roe, 1994). Over the last 50 years, research has focused on lake-margin occupations during Beds I and II, but little is known about the archaeology of fluvial facies (Blumenschine et al 2003). This paper presents new data from fluvial channel deposits and associated floodplains and paleosols. In the western basin, the site of Ewass Oldupa (Geolocality 63: Hay 1976) consists of stacked channel deposits capped by fine-grained sediments, well-drained paleosols, and thin lacustrine claystones spanning Beds I and II and several marker tuffs, likely including Tuff IB (Blumenschine et al 2003; Deino 2012). Excavation yielded quartzite and basalt cores, spheroids, flakes and fragments. The fauna in Bed I includes papionini (*Theropithecus oswaldi*), bovids, ostrich, birds, and rodents. They deposited in ephemeral, sinuous channels that migrated across the floodplain in a landscape covered by woody taxa, ferns and some grasses, as shown by phytoliths. In the eastern basin, at Engaji Nanyori (Juma Korogo: Leakey 1965; Kleindienst 1973; Leakey 1971; Blumenschine et al 2008; Pante 2013) fluvial channels and paleosols alternate throughout Bed III to its base (Dominguez-Rodrigo et al 2013), and partly in lower Bed IV. We retrieved lithics composed of quartzite, chert, phonolite, and basalt including several handaxes, polyhedrons, and anvil fragments, as well as flakes and fragments of quartzite, phonolite, basalt, trachyte, and obsidian, with bipolar reduction present. The archaeological locus straddles the confluence between streams draining western and eastern sources, and is locally represented by amalgamated channel-belts up to 200m wide. The floodplain's vadose zone was colonized by shrubs, as indicated by root casts. Phytogenic silica from leaf and woody tissue is in pristine condition and suggests an evergreen riparian forest. The fauna comprises hippopotamus, crocodiles, perciform fishes, equids, and bovids.

**Frahm et al.**

## **Walking from New York City to Knoxville: Origins of Late Pleistocene obsidian artifacts at Ortvale Klde (Georgia) and increased scales of interaction from the Middle to Upper Paleolithic**

The stratified Late Pleistocene cave site of Ortvale Klde offers unique opportunities to directly test hypotheses involving behavioral rifts and continuities between Middle and Upper Paleolithic (MP and UP) hominins in the South Caucasus. To examine differences in mobility and social interactions, we sourced >500 obsidian artifacts. Approximately 96.7% of MP and 77% of UP artifacts match the nearest source: Chikiani in southern Georgia (~120 km away linearly, >180 km on foot). The next most frequent source lies in the Kars region of northeastern Turkey (~200 km away linearly, >300 km on foot), represented by 3.3% of the artifacts in MP strata and 22.8% in UP strata. In UP strata of Ortvale Klde, we identified artifacts from two distant sources — Hatis in central Armenia (~250 km linearly, >400 km on foot) and Meydan Dağ in eastern Turkey (~350 km linearly, >550 km on foot) — that are also present among UP lithics at Aghitu 3, a cave site in southern Armenia. Hence, occupants of Ortvale Klde and Aghitu 3 (~400 km apart linearly, >580 km on foot) tapped into a shared flow of material and people, albeit to a limited extent. The farthest UP source is Nenezi Dağ in central Turkey. It is ~900 km linearly and >1100 km on foot away, equivalent to walking from New York City to Knoxville, Tennessee. No artifacts match the Baksan source, ~90 km linearly to the north. Such obsidian occurs at MP and UP sites in Russia, across the Northern Caucasus, which served as an effective barrier. Thus, while isolated from populations immediately to the north, the UP occupants of Ortvale Klde, unlike their MP predecessors, seem linked, via an extended network, to Central Anatolian populations. Therefore, we observe considerable and consistent differences in the mobility and social interactions of MP and UP hominins.

**Gill et al.**

## **Nothing from Nothing Ever yet was Born: A Morphometric Exploration of Evolutionary Relationships between Biface and Core Technology at Nor Geghi I, Armenia**

This study applies a three-dimensional landmark-based geometric morphometric (GM) technique to explore morphological relationships between biface and core technology during the Lower to Middle Palaeolithic transition in Armenia. This analysis utilizes 360° documentation of shape to supplement more commonly used single-surface and outline GM approaches. Furthermore, traditional quantitative and qualitative analyses are used to contextualize variation and continuity between artifact classes documented by GM. Structured light 3D-scanning is employed in this research to obtain highly-accurate models of artifacts from Nor Geghi I (NGI), a site previously described as showing the in situ transition between Acheulian (Mode 2) and Levallois (Mode 3) technology. Assemblages from NGI locus-north (MIS 9e) and locus-south (~MIS 11) are used to explore the relationship between terminal Acheulian bifaces and early Levallois cores. Hatis I, a pre-transitional Late Acheulian site, is included in this analysis to show regional trends in biface form leading into the transition. It has been argued that Mode 3 is fundamentally embedded in the underlying Mode 2 and is realized through a combination of formally separate systems of façonnage and débitage. It has been further suggested that Levallois is the outcome of both conceptual evolution and an actualized morphological evolution from handaxes to cores. Finds in Late Acheulian contexts in other regions are argued to represent transitional forms, presenting as handaxes with preferential removals and simple prepared cores. Assemblages from both NGI loci contain handaxes, Levallois cores, and both of these transitional forms. Principal component and corresponding statistical analysis show close morphological relationships between Levallois, Acheulian, and both of the suggested intermediate forms. As this research accounts for raw material and resharpening behaviors as alternative explanations for morphology, Levallois core technology at NGI is best understood as being the evolutionary outcome of the conceptual and morphological variation in the underlying Acheulian technocomplex.

**Gorgone et al.**

## **Medial cuneiform morphology reflects ecological divergence between Virunga and Bwindi mountain gorillas**

Mountain gorillas (*Gorilla beringei beringei*) live in two geographically discontinuous populations that inhabit the Virunga Massif of Rwanda, DR Congo and Uganda, and Bwindi Impenetrable National Park in Uganda. Though separated by just 35 km, the ecology and behaviors of these two populations vary in relation to altitudinal elevation; compared to Virunga gorillas (2630-3850m), Bwindi gorillas (1,160-2,600 m) show increased frugivory, vertical climbing and longer day ranges. Here we test the hypothesis that mountain gorilla foot morphology varies in relation to differences in vertical climbing. Compared to the Virunga population, we predict that Bwindi gorillas will exhibit talocrural and hallucial tarsometatarsal joints that facilitate a more medially oriented foot set and greater mobility of the hallux, respectively. Our sample includes three-dimensional models derived from recently-recovered skeletons of Bwindi gorillas (N=8), and Virunga gorillas (N=25) from Volcanoes National Park, Rwanda. The hallucial facet on the medial cuneiform was significantly more curved in Bwindi gorillas ( $p = 0.015$ ), but the trochlear facet on the talus was not significantly different from that of Virunga gorillas ( $p = 0.15$ ). Overall these findings suggest that differences in local ecology play a role in determining population-level variation in functional morphology of the hominoid foot skeleton, which has relevance for understanding the behavior and ecology of extinct taxa.

**Hallett**

## **Taphonomy and zooarchaeology of the vertebrate faunal remains from Middle and Later Stone Age deposits at Contrebandiers Cave, Atlantic Coast, Morocco**

Contrebandiers Cave is located in the town of Témara, on the Atlantic coast of Morocco, roughly 250 m from the current shoreline. The cave was excavated in the 1950s and 1970s by l'Abbé Jean Roche, and again starting in 2007 by Harold Dibble and Mohamed El Hajraoui with total station plotting of finds. Contrebandiers Cave contains Middle Stone Age (MSA) Maghrebian Mousterian and Aterian industries deposited ~126,000-95,000 years ago during Marine Isotope Stages (MIS) 5e, 5d, and 5c, and a Later Stone Age (LSA) Iberomaurusian industry dated elsewhere to MIS 2, ~20,000 years ago. The entirety of the ~12,000 vertebrate faunal remains from Dibble and El Hajraoui's excavation were analyzed for taxonomic and taphonomic identification, and the results are presented here. A total of 67 vertebrate taxa were identified, and taphonomic analyses reveal that ungulates, carnivores, small mammals, birds, tortoises, snakes, and fish were accumulated by both human and carnivore agents. Skeletal element representation and surface modification of ungulate and tortoise remains suggest that humans had primary access to large, medium, and small-bodied prey. This research includes a discussion of the changes in human diet and subsistence strategies over time and between MSA and LSA industries at Contrebandiers Cave. The vertebrate faunal remains from MIS 5e and 5d indicate that humans were hunting grazers and mixed feeders from open and mixed habitats, while the faunal remains from MIS 5c suggest an increased focus on prey from open habitats. The vertebrate faunal remains from MIS 2 suggest a dry, open habitat in proximity to the cave.

**Harris et al.**

## **An updated Bayesian model of bone surface modification and application to the "Dikika Marks" (Ethiopia, 3.4 Ma)**

Identifying pivotal transitions in hominin evolution, such as the origins of tool-assisted butchery and the nature of carcass access (hunting versus scavenging), relies upon the ability to accurately identify bone surface modifications (BSM). However, because BSM can be subject to the principle of equifinality, the ability to confidently assign agency to BSM recovered in fossil contexts remains one of the most debated topics in paleoanthropology. In previous studies, we provided Bayesian probability models to analyze, identify, and report on BSM (Harris et al., 2017), and later combined 3D-Geometric Morphometrics (3DGM) with Bayesian inference (Otárola-Castillo et al., 2018). Bayesian inference allows probability-based assignment of agency to individual BSM, while 3DGM reduces subjectivity in BSM shape description. Moreover, probabilistic modeling of shape and size contextualizes BSM studies within a transparent and replicable causal framework. These approaches represent a theoretical paradigm shift in BSM studies and provide a foundation for incorporating new forms of BSM data into subsequent models. We present an updated probability model of BSM using 3DGM. Our current model is trained on large samples of experimentally generated BSM from crocodile feeding, large ungulate trampling, and human butchery with unmodified rocks. We limit our sample to BSM known to exhibit a high degree of equifinality (cut-mark mimics) and demonstrate the discriminatory ability of the updated model. Finally, we apply this model to the controversial surface modified bones from the 3.39 Ma DIK-55 site at Dikika (Ethiopia), published by McPherron et al. (2010).

**Hartman et al.**

## **Reconstructing the hunting ranges at the Early Upper Paleolithic site of Mughr-el-Hamamah, Jordan**

The site of Mughr-el-Hamamah (MHM) is located above the Jordan Valley (+80m amsl), on the western slopes of the Transjordanian plateau in the Ajlun Governate, Jordan. The site dates to 45-39kya (<sup>14</sup>C Cal Intcal13), positioning it among a handful of Levantine sites that provide evidence for the transition to the Upper Paleolithic. Exceptionally dense faunal and lithic assemblages from secured contexts provide a unique opportunity to reconstruct the hunting territories of MHM occupants using the isotopic composition of commonly hunted mountain gazelle (*Gazella gazella*) and fallow deer (*Dama mesopotamica*). Our results indicate a well-defined and highly localized region of animal procurement. Gazelle hunting took place locally at low and

intermediate elevations around the site. Deer hunting took place in a narrow elevational band immediately above the highest location from which gazelle were hunted. This suggests that the elevation-dependent transition from gazelle to deer hunting is associated with the position of the forest that covered the higher slopes. It also appears that the deer hunting was restricted to the shortest possible distance from the site. This coincides with the zooarchaeological observation that hunted deer carcasses were transported to the site as complete carcasses. The hunting range utilized by the occupants of MHM covers an ecotone environment over an area of roughly 150 square kilometers.

**Haws et al.**

## **Earlier than we thought: the Early Aurignacian technocomplex at Lapa do Picareiro (Portugal) and the arrival of modern humans in southwestern Iberia 40,000 years ago**

The arrival of anatomically modern humans (AMS) in western Eurasia remains an intensely debated archaeological problem. For over two decades, Zilhão's(1) "Ebro Frontier" model of late Neanderthal survival in southern Iberia and subsequent replacement by AMS has held sway. This model, and others, are open to debate because of persistent problems with stratigraphic integrity, depositional hiatuses, and dating uncertainties at the relevant Middle-Upper Paleolithic transitional sites. New radiocarbon dates from these sites have forced a rethinking of Neanderthal survival after 40 kya. Here we present new evidence of an Early Aurignacian occupation, documenting an anatomically modern human presence in SW Iberia 5,000 years earlier than previously known. Our excavation of Lapa do Picareiro has revealed 10m of sediments spanning 50,000 years of the Late Pleistocene. In 2018, we detected the presence of an Upper Paleolithic occupation stratigraphically positioned between a Middle Paleolithic occupation dated 47-45 ka cal BP and an undiagnostic archaeological level dated 36-38 ka cal BP. The lithic assemblage is characterized by a carinated endscraper or bladelet core and unretouched bladelets all made on chert. The occurrence of these elements indicates a previously unknown Early Aurignacian presence in central Portugal. Magnetic susceptibility data suggest the occupation took place during the H4 cold event. These finds complicate recently published scenarios by Wood et al. 2013 (2), Zilhão et al. (3) for sites in southeastern Spain and Angelucci and Zilhão (4) for the nearby Gruta da Oliveira. Taken together, the emerging chronostratigraphic scenario allows for several possibilities including a northern Iberian transfer of the Aurignacian technocomplex through Euro-Siberian ecosystems that extended along the west coast of Iberia during cold phases of the Late Pleistocene. The finds do not necessarily discount models for late Neanderthal survival in southern Iberia after H4, but suggest the distinct possibility of coexistence with modern humans.

**Herries et al.**

## **Acheulian artifacts and associated wood from Amanzi Springs, Eastern, Cape South Africa.**

The Amanzi Springs Acheulian site consists of a series of 11 spring eyes located on a shallow hill near the town of Uitenhage in the Eastern Cape of South Africa. Two of the spring eyes, Area 1 and 2, were excavated by Hilary Deacon in the 1960s as his Masters project. These excavations revealed Acheulian artifacts in a rare stratified context for South Africa, as well as potentially related wood; one of only 2 places in Africa where wood is preserved with the Acheulian. A recent project has started work on both dating the spring deposits, clarifying the stratigraphic context of the artefacts and wood, and exploring other spring eyes. Our work indicates there is a direct association between wood and Acheulian artifacts in one of the new spring eyes, Area 7. It also reveals a previously unidentified transitional and Middle Stone Age component to the site. Details of these findings will be presented along with preliminary dates

**Hlubik et al.**

## **Preliminary results of phytolith analysis at FxJj20 AB, Koobi Fora, Kenya: environmental reconstruction and implications for studying fire in the archaeological record**

There is substantial debate about the use of fire in the Paleolithic. Numerous proxies of ancient combustion have been investigated in Pleistocene but many of these do not preserve in open air localities. Phytoliths have potential for recording the presence of combustion. These silica-based microbotanical remains are particularly informative because they reflect the proximate environment, and can be used to create a detailed picture of past environments. Phytoliths are used in many contexts to provide specific data on plant families and sometimes species present within a sample, and can indicate the presence of fire, as they change color at temperatures above 700°C. The spatial relationship between burned phytoliths and combustion features in the archaeological record is poorly understood. This is especially the case in situations where the sedimentary record of archaeological sites reflects multiple instances of time averaging. Previous research has shown that these materials can be recovered from various depositional environments and from sediments of various ages, but recovery from Early Pleistocene open air archaeological sites has been limited. We present here pilot research assessing the presence of phytoliths on FxJj20 AB in Koobi Fora, Kenya and whether evidence of burning can be detected in phytoliths recovered from the site. Preliminary results indicate that phytoliths are present in association with other archaeological remains from the site, and that these phytoliths differ from the assemblages of modern phytoliths identified on the modern landscape around the site. We identify spatial variance in the forms and degree of burning found on the site. Several of the phytoliths recovered from the excavated sample indicate the presence of combustion. We report the results of this work and explore how the variability in the presence of burning on the site is reflective of the presence of fire on the ancient landscape.

**Hodgkins et al.**

## **A new Upper Paleolithic infant burial from Arma Veirana, Liguria, Italy**

In 2018, a modern human infant burial was excavated from an Upper Paleolithic level at the cave site of Arma Veirana in the Liguria region of northwestern Italy. As Arma Veirana was discovered recently (excavations began in 2015), its excavation used cutting-edge methods including 3D GIS mapping using total stations, georeferenced photogrammetry, and micromorphology, which provided detailed documentation of the burial and its context. Radiocarbon samples indicate that the burial dates to the end of the Pleistocene or early Holocene, consistent with a Final Epigravettian/Early Mesolithic chronocultural attribution. The body was placed within an artificial pit, the outline of which could be followed during excavation. Much of the skeleton was in articulation; thus, although the burial pit was partially eroded, the remains were largely undisturbed. Most of the cranial vault was recovered (albeit partially crushed by sediment impaction) along with long bone shafts, axial elements, hand bones, and isolated deciduous teeth. Initial estimates based on skeletal and dental development place the infant at a likely age of < 3 months. In addition to the infant, the pit contained over 80 pierced *Columbella rustica* beads and four larger pendants made on polished *Glycymeris* sp. shell arranged in an articulated series. An array of additional items included in the grave (e.g., ochre, stone tools, carnivore phalanges, and a raptor talon) indicate that the young infant was a culturally significant individual. Some of the grave goods are particularly striking as analogous artifacts are lacking in the Upper Paleolithic record of Eurasia. Moreover, the large size of the pendants relative to the infant further suggests status. As such, the Arma Veirana infant provides an important glimpse into funerary practices in the time spanning the Final Epigravettian and Early Mesolithic.

**Hoffecker and Hoffecker**

## **Does computation theory provide an interpretive framework for Paleolithic archaeology?**

Computation theory is applied to natural and artificial systems, including organic evolution, language, and automata. The theory began with a 1936 paper by Turing containing a simple model for a computer (or “universal machine”). Twenty years later, Chomsky (1956) proposed three models for language that were integrated with Turing’s concept to create the “Chomsky Hierarchy”

of formal models in computation theory. Beginning in the 1960s, various researchers developed approaches to the evolutionary process as a special form of computation or “evolutionary computation” (De Jong 2006). We suggest that models in computation theory and evolutionary computation may be applied in Paleolithic archaeology to: (1) measure the underlying computational complexity of artifacts, and (2) identify major transitions in Paleolithic technology. Most Lower Paleolithic artifacts may be generated with the equivalent of a “finite-state” grammar. After 0.5 mya, there is evidence for composite artifacts, which require more computational power, including working memory and “rewrite” rules, equivalent to Chomsky’s (1956) “phrase-structure grammar” model (“context-sensitive” variant). Composite artifacts represent a major transition in technological computation, entailing translation of a complex body of information in the brain to a material structure outside the brain, analogous to the development of an organism based on genetic information. After 0.1 mya, there is evidence for self-acting devices that meet the formal definition of a machine (e.g., snare). We identify the machine as the second major transition in technological computation and characterize it as “computational technology” because it: (1) represents a new level of computation (i.e., the artifact itself performs a computation), and (2) reflects computation with objects analogous to language computation with speech sounds. Machines are developed through an evolutionary computational process of experimental trial-and-error, entailing recursive variations in a controlled dynamic system that reveal cause-and-effect relationships among the moving components, i.e., causal analysis (Pearl 2009).

**Huang et al.**

## **An experimental use-wear analysis of drilled gastropod operculum using 3D microscopy and its implications for Middle Stone Age symbolic behaviour**

Some of the earliest evidence for symbolic behaviour in human prehistory comes from personal adornments made from shells. More than 400 opercula from the terrestrial gastropod *Revoilia guillainopsis*, were found at the Middle Stone Age site of Porc-Epic in southeastern Ethiopia (Rosso et al., 2016). The opercula, unbroken except for a central perforation, resemble disc beads made from materials like ostrich eggshell (Miller and Willoughby, 2014) and terrestrial snail whorl shell (Miller et al., 2018). Microscopic analysis of the opercula could not determine if they were anthropogenically manufactured or used as beads due to the lack of an experimental reference collection for this novel substrate (Assefa et al., 2008). For the present study, we experimentally tested whether the opercula found at Porc-Epic were anthropogenically modified. We hafted knapped basalt drills on wooden dowels using artificial sinew and gum arabic. We used these composite tools to manually drill through *Turbo smaragdus* opercula. Prior to drilling, we photographed and measured the opercula for comparison to our experimental results. After drilling, we analyzed the experimentally-modified opercula using a 3D optical scanner. Further, we compared these experimental surface scans to archaeological drilled shell beads from the southwest United States. Our experiment showed that drilling creates distinctive striations that differ from the modifications on the opercula from Porc-Epic. While this contradicts our hypothesis that the opercula were anthropogenically drilled, the alternative hypothesis that the central perforations are caused by predatory octopods or gastropods is unlikely; observational and experimental work has found that predatory drilling usually occurs directly through the shell whorl or around the edges of the operculum (Steer et al., 2003; Vermeij and Williams, 2007). While their use as beads cannot yet be proven, our preliminary findings suggest that the perforated opercula of Porc-Epic were likely modified by humans, possibly with symbolic motivation.

**Johnson et al.**

## **Testing for inter- and intra- observer error in bone fracture angle measurement data**

To better understand hominin meat processing in the prehistoric record, bone breakage has been studied at many important archaeological sites for human evolution like FLK *Zinjanthropus* and Swartkrans. Calculating the inter- and intra-observer error rates of data extraction protocols is necessary for evaluating measurement bias and how it affects taphonomic data analysis and subsequent interpretations of important early human behavior. Interobserver error has been studied for many different taphonomic approaches, such as surface mark identification. In the case of breakage, such analysis is limited, especially as it pertains to fracture angle (Alcántara García et al., 2006) measurement. Coil (et al., 2017) tested the measurement of fracture angles for inter- and intra-observer error. Coil and colleagues found no statistically appreciable difference in inter- or intra-observer bone fracture angle



measurements. However, the study focused solely on elk (*Cervus canadensis*) bones broken by hammerstone and anvil. Here, we analyze inter- and intra-observer error for an expanded sample of elk and cow (*Bos taurus*) bones broken by spotted hyena (*Crocuta crocuta*); hammerstone and anvil; rock fall; and batting to determine if variability in fragmentation by taxon or agent of breakage impacts error rates when measuring fracture angles. Three analysts, with varying levels of experience, collect the following data on bone fragments from elk and cow femora, humeri, radius-ulnae, and tibiae: (1) number of breaks per fragment, (2) maximum break length, (3) break plane (longitudinal, oblique, transverse), and, (4) fracture angle. Significant differences in the measurements made by different analysts would suggest the need for greater standardization in the methods used in bone fragment analysis.

**Keller et al.**

## **Nutritional stress and marine exploitation: subsistence strategies at KEH-1, South Africa, during the Middle and Later Stone Age transition**

Knysna Eastern Heads Cave 1 (KEH-1) demonstrates varying human occupation over the course of multiple ocean transgressions and regressions dating between 46,000 - 18,000 Cal BP. The position of the sites on the shallow South African coastal shelf offered occupants potential access to riverine, coastal, and terrestrial resources, as high and low sea stands drastically altered the location of these resources. It has been hypothesized that the dearth of sites dated to MIS 2 on the south coast, a time when the ocean was 75-90 km distant, is due to a preference for dense and high protein marine resources, drawing early modern humans out onto the now-submerged Paleo-Agulhas plain. Possible explanations for the continuous occupation at KEH-1 during this time are 1) that use of marine foods was only one of several subsistence strategies employed by early humans; 2) the intersection of terrestrial and riverine resources around Knysna rivaled coastal resources; and 3) competition and territoriality caused by dense marine resources on the coast forced groups into the interior. To examine these explanations, faunal remains deposited during the MIS 3-2 transition at KEH-1 were examined for variation in the intensity of long bone marrow processing as a proxy for changing nutritional stress. Approximately 2400 faunal specimens were analyzed across the sequence. Although the degree of post-depositional fragmentation varies throughout the sequence, the high rate of long bone fragmentation (84% with an incomplete circumference) at KEH-1 is most likely caused by human processing, with minimal carnivore activity. The higher frequencies of green fractures when the coastline was distant (54% and 55%) are statistically significantly different from frequencies when the coast was near (31% and 43%,  $\chi^2=2804$ ,  $DF=16$ ,  $P=0$ ). These results suggest that the long bones were processed more intensely during glacial periods, despite the availability of diverse terrestrial resources.

**Kelsey et al.**

## **The lithostratigraphy of the Middle Stone Age in the northeastern Turkana Basin**

The Koobi Fora Formation of the northeastern Turkana Basin provides a largely continuous fossil- and artifact-rich volcanoclastic sequence allowing for the investigation of morphological and behavioral evolution during the Plio-Pleistocene. Recent and ongoing archaeological investigations have documented in situ evidence of early modern humans in the region, as demonstrated by Middle Stone Age (MSA) stone artifacts (Ranhorn et al, 2018; Kelly and Harris 1998). However, our current understanding of these Middle-Late Pleistocene deposits is severely limited by numerous unconformities coupled with a general lack of stratigraphic control. We conducted targeted geo-survey throughout the Karari and Koobi Fora sub-regions to investigate the geology of the upper portion of this sequence and contextualize the MSA record of the northeastern Turkana Basin. We collected stratigraphic, elevation, and structural data (strike and dip) of marker deposits enabling a high-resolution understanding of MSA-bearing sediments over a laterally expansive area (ca. 60 km). Our results demonstrate MSA-bearing deposits in primary contexts found in all sub-regions of the basin associated with indurated sandstones and *Gastropodia/Bivalvia* horizons. We traced these laterally continuous deposits near well-known archaeological localities (e.g. FxJ12/12N). Our sedimentological facies analyses indicate a shore/nearshore-environmental provenance for this MSA paleo-surface. Subsequent Holocene high lake stands caused significant redeposition of these underlying Middle-Late Pleistocene sediments, and as a result these deposits remain variably intact across space, ranging from multiple meters thickness in some localities to complete deflation in others. Our preliminary dating results, based on optically stimulated luminescence (OSL) (Colarossi et al 2018) indicate MSA-bearing deposits in two occupational lenses, dating to >100 ka in the Karari and 70-30 ka in Koobi Fora. In sum, our regional-scale stratigraphic reconstruction significantly extends our understanding of the Middle-Late Pleistocene record of Turkana and is a crucial step in contextualizing the MSA archaeological record in this region.

## **Kitagawa and Conard**

### **Why the quantum leap? Organic technology of the Aurignacian in the Swabian Jura**

The Swabian Jura is renowned for having the richest Aurignacian record in Central Europe. The Aurignacian toolkits reflect the prevalent use of hard tissues from animals, which enriched the artifact assemblages relative to the preceding Middle Paleolithic assemblages. Here, we analyze the organic tools of the Swabian Aurignacian to determine the functions and the production sequence of the artifacts. We also consider the choices of raw material and explore several hypotheses that help explain the variability in the size and form of organic tools. In summary, antler, bone, and ivory were employed in hunting and domestic activities at sites with higher occupational intensity including Vogelherd, Geißenklösterle, and Hohle Fels. The majority of the common tools is found in the Aurignacian toolkits across Europe. Tools which are unique to the region include antler retouchers and pointed tools made from mammoth ivory. This analysis demonstrates the systematic use of organic tools and the standardization of artifacts across different regions, while also highlighting unique developments in the organic technology of the Swabian Aurignacian.

## **Leiss et al.**

### **Paleoecology of OGS-12, an Early Acheulian archaeological site at Gona, Ethiopia.**

The Acheulian stone tool complex first appears in the East African archaeological record at ~1.75 Ma from Kokiselei, Kenya, and Konso, Ethiopia. It marks the beginning of tool making with a preconceived notion of form and is thought to coincide with the evolution of *Homo erectus*. Despite being one of the most important transitions in early human prehistory, little is known of the behavioral and environmental background of its emergence. The data presented here, collected from fauna excavated at Ounda Gona South 12 (OGS-12), an early Acheulian site from Gona, Ethiopia, and collected in nearby contemporaneous paleontological sites help us to contextualize and better understand this transition. OGS-12 is estimated ~1.6-1.5 Ma with two tuffs in the section below the site yielding age estimates of 1.9 Ma and 1.64 Ma (Quade et al., 2008). A total of 315 bones were identified to element (NISP-E) and were included in a taphonomic analysis (Cáceres et al., 2017). The presence of indicator taxa of bovids, hippo, crocodile, and cane rat depict the paleoenvironment as near a perennial water source close to open areas suitable for grazing as well as a more wooded component. This is fairly consistent with findings presented by Quade et al. (2004, 2008) that associate OGS-12 with a Type II tributary channel of the ancestral Awash River. Updated more in depth analyses of the fauna, comparing excavated assemblages to surrounding paleontological assemblages, including abundance data and ecomorphometrics are presented. Evidence of anthropomorphic bone modification (bone marrow extraction, cut marks), high degrees of fragmentation, green fractures, a high proportion of low-density elements, along with a low ratio of carnivore to hominin marks indicate that hominins were processing animal carcasses at OGS-12 and appear to have been the dominant accumulative agent of this assemblage.

## **Li et al.**

### **Force and Flake Size. Implications for Hominin Strength**

One of the hallmarks marking the appearance of the Early Acheulean is the ability to consistently produce large flakes, often >10cm. Flake attributes and methods of production have long been a focus of numerous studies of the archaeological record and in controlled experiments. Less attention has been given to an accurate measurement of the amount of force needed to detach flakes from a core. Dibble and Rezek (2009), however, observed that the amount of force required to remove a flake is related to its size. Our recent controlled experiments on the role of raw materials in flake production show a positive correlation between force and flake size for four different raw materials (glass, flint, obsidian, and basalt), which supports Dibble and Rezek (2009)'s observation. In a new controlled experiment, flakes were knapped with a servo-hydraulic press while measuring the maximum force used to detach flakes of various sizes in obsidian, basalt, flint, andesite, and banded ironstone. The variables measured were exterior platform angle, platform depth, angle of blow, and force. Previous controlled experiments made relatively small flakes, but in this experiment, we collected force data on larger flakes to extend the current force-flake size correlation. Pilot data on force from modern human swings also were collected and compared to the experimental data. The relationship between force and flake size

can help determine the force needed to produce large Acheulean flakes and provide the association between large flake production and hominin strength. Decreased hominin strength appears to be coincident in timing to changes in flake sizes, with stronger skeletal dimensions in earlier hominins than in modern humans. These results have implications for the potential for hominins to produce, without using a technological aid, some of the very large flakes found in the archaeological record.

**Martisius et al.**

## **Non-destructive ZooMS identification reveals bone tool raw material selection by Neandertals**

In 2013, we reported the discovery of four nearly identical fragments of bone from two Middle Paleolithic sites in southwest France, Pech-de-l'Azé I and Abri Peyrony (Soressi et al. 2013). We identified these fragments as specialized bone tools, or lissoirs (a term meaning "smoothers" used in the French typology for bone tools). These finds span three discrete archaeological deposits, suggesting continuity in the behavior of these late Neandertals. Using standard morphological assessments, we determined that the lissoirs were produced on ribs of medium-sized ungulates. However, since the bones were highly fragmented and modified, species determinations based on morphology alone were challenging. In addition, conservative curation policies often limit or prohibit destructive sampling of rare, fragile, and fragmented artifacts for molecular identification methods. Therefore, to better understand raw material selection for these four previously published lissoirs, and a fifth example recently found at Abri Peyrony, we assessed their taxonomy using a modified Zooarchaeology by Mass Spectrometry (ZooMS) methodology (Buckley et al. 2009; Welker et al. 2016). We employed an entirely non-destructive method based on the triboelectric capture of collagen on the plastic storage containers used to curate the artifacts. This method yielded identifiable MALDI-TOF MS collagen fingerprints for all four Abri Peyrony lissoir samples. Significantly, these samples all produced spectra indicative of the same taxonomic clade, which includes aurochs and bison (*Bos* sp. and *Bison* sp.). The fauna found in association with three of the four Abri Peyrony lissoirs is dominated by reindeer, yet Neandertals repeatedly chose to manufacture and possibly curate lissoirs from larger bovid ribs. The results of this study demonstrate that these Neandertals specifically selected raw materials for producing bone tools. Furthermore, our results highlight the value of a promising new technique for the non-destructive analysis of bone artifacts.

**McGrath**

## **A comparison of two Late Pleistocene ochre records from South Africa**

Archaeological ochres are generally interpreted as indicating a range of symbolic or utilitarian tasks. Research on these materials has featured prominently in identifying the emergence of Behavioral Modern Humans, while research into the diachronic and synchronic variation in ochres use is less common. This poster presents the results of a comparative analysis of ochre assemblages between two South African Late Pleistocene sites located in relative proximity, but differing environmental contexts: Boomplaas Cave (BPA) and Pinnacle Point 5-6 (PP5-6). Both sites contain contemporaneously dating deposits between MIS 4 and 3 and have benefited from recently refined age models. Results are reported here on the comparison of ochre frequency, nodule size, nodule weight, and rates of modification for overlapping periods. These results are considered in light of recent arguments for Late Pleistocene demographic variation and reports of increased signaling behaviors during the Howiesons Poort.

**Mentzer and Wurz**

## **Differential preservation of anthropogenic deposits in Cave 2, Klasies River Main Site (South Africa)**

Klasies River Main Site (South Africa) is well-known for its thick sequence of archaeological deposits contained within two cave chambers and two rockshelters, and ranging in age from MIS 5e to Holocene. Cave 2 is located at the highest elevation within this complex. The cemented and eroded sediment within the chamber is rich in artifacts attributed to the Howieson's Poort technocomplex. Differential preservation of shell and bone was reported by Singer and Wymer, and later Deacon during excavations of the sequence. Deacon and Geleijnse (1988) hypothesized that the location of alkaline dripping water within the

chamber aided in the preservation of carbonate in the western deposits. Here we revisit this observation using micromorphology and geochemical analyses of the sediments. Micromorphological blocks and loose sediment samples were collected from both sides of Cave 2 in 2015. Blocks from the western side contain abundant shells, several intact hearths, and thin layers of phosphatic material, with broad similarity to deposits in other areas of the site. Blocks from the eastern side contain a repetitive sequence of charred material overlain by cm-scale layers of soft, white and yellow authigenic minerals. Fourier transform infrared (FTIR) analyses yield an identification of leucophosphite, and its dominance within the yellow and white layers is confirmed by micro-x-ray fluorescence mapping. This potassium iron phosphate has been hypothesized to form from alteration of wood ash in the presence of phosphatic solutions derived from bird or bat guano (Karkanas et al. 2000). These results indicate that the post-depositional processes in the eastern side of the Cave 2 chamber are anomalous relative to the rest of the site.

**Monnier et al.**

## **New Excavations at Crvena Stijena, Montenegro: a multidisciplinary investigation of fire use by Neanderthals in Southeastern Europe**

The rock shelter of Crvena Stijena (“Red Rock”) in Montenegro has one of the longest and best-preserved Middle Paleolithic (MP) sequences in southeastern Europe. It is located in the Dinaric Karst in the southwestern part of the country, at 700 meters a.s.l. and 32 km from the present Adriatic Sea. Excavations in the mid-20th century uncovered a stratified sequence of archaeological layers over 20 meters deep, spanning the Middle Paleolithic through the Bronze Age (Brodar 2009; Basler 1975). The resulting lithic collections have made Crvena Stijena a type-site for the southern Balkans (Mihailović 2009; Mihailović & Whallon 2017; Dogandžić & Đuričić 2017). Subsequent excavations by Robert Whallon and colleagues (Baković et al. 2009) from 2004-2015 produced the first detailed absolute chronology for the site, studied the stratified hearths and extensive faunal record, and documented the presence of the Y5 tephra capping the Middle Paleolithic deposits (Whallon 2017; Morley & Woodward 2011). Importantly, this work removed sterile overburden, allowing access to the Middle Paleolithic layers that span 40-80 kya. Our new project applies a multitude of approaches to characterize Neanderthal behavior at the site, particularly with regards to pyrotechnology. We are testing the controversial hypothesis that Neanderthals used fire only when it was available in their environment (Sandgathe et al 2011, Dibble et al 2017). We also aim to achieve a better general understanding of Neanderthal fire use at the site. Paleoenvironmental reconstruction is based upon faunal analysis, phytolith analysis, biomarker analysis from sediments, and charcoal analysis. Pyrotechnological behaviors are reconstructed through micromorphology, mineralogical analysis of sediments and heat-altered artifacts, and archaeomagnetic analysis of combustion features. Multiscalar photogrammetry is used every 2cm to allow the calculation of sediment volume despite large clasts. Preliminary results from 2016-2018 will be presented.

**Morin et al.**

## **New evidence for recurrent dietary exploitation of leporids in the Middle and Late Pleistocene of the Northwestern Mediterranean**

In Europe, it is widely assumed that the dietary exploitation of small fast prey taxa was anecdotal during the Lower and Middle Paleolithic. In this model, medium- to large-sized herbivores (e.g., bovids, equids, cervids) are presumed to have formed the bulk of the diet of archaic hominins. Studying a wide range of potential prey taxa is important because small fast animals are difficult to capture, and therefore, may signal attempts at intensifying animal resource exploitation (Jones 2006; Cocharde et al. 2012). To assess whether the view that small fast game were rarely procured by archaic hominins is correct, we examined 21 leporid assemblages from eight sites in Southern France dated to the Middle and Late Pleistocene. This region is particularly relevant for this test, given that naturally-accumulated assemblages suggest that rabbits were frequently encountered in the area during this time period. Along with new, recently published evidence from Iberia and Southeastern France (Blasco and Fernández Peris 2012; Martínez Valle et al. 2016; Romero Díez and Brugal 2017), our results indicate that small fast game procurement was considerably more common in the Northwestern Mediterranean than assumed by most current models of human evolution. This finding has important implications for our understanding of variation in human diet breadths during the Middle and Late Pleistocene.

**Morong et al.**

## **A preliminary analysis of Holocene burials from West and East Turkana**

Burial practices allow for a deeper understanding of interaction between humans and their understanding of mortality as well as providing a glimpse into group memory of ancestral members of a community. Identifying these components of ancient burial practices is particularly difficult because we rarely recover contextual details in ancient locales. Due to these difficulties, it is imperative to study the patterns exhibited in younger burials that may reflect similar contexts, social structure, and behaviors. One such locale where burial practices are well documented is the Holocene burials in the Turkana Region of Northwest Kenya. In particular, the burials found in situations where communities are transitioning between hunter-gatherer subsistence strategies and pastoralist lifeways provide key insights into how burial practices vary in relation to changes in subsistence. Excavations have uncovered various material artifacts as well as skeletal remains that illustrate the variability of mortuary practices within this region. Analysis of early Holocene burials in the Lothagam sites of West Turkana have been used as a baseline for comparisons of recent excavations of Holocene burial sites in East Turkana. These burial sites have been previously noted, but rarely investigated in detail. The goal of this work is to reveal the similarities and differences among Holocene burials from the West and East sides of the Lake Turkana. Differences include ages of individuals found buried, material artifacts associated with the burials, and the burial style. Our research aimed to discover how climate variability of the region would impact the cultural elements associated with burial practices and the trauma found on certain skeletal remains. Using research gathered during a 2018 field season, and comparative analysis of the Lothagam remains, this presentation will compare and contrast the burials discovered in West and East Turkana.

**Murray et al.**

## **An agent-based modeling approach to explain the rarity of projectile points in archaeological sites**

It is thought that the invention of projectile technology provided an evolutionary advantage to modern humans that appeared in the Middle Stone Age (MSA). MSA points have traditionally been thought to be projectiles, though use-wear studies suggest they were used as both knives and projectiles. Because of their perceived importance, MSA points are considered to be a defining feature of the MSA, yet they are typically rare in the caves and rockshelters that dominate our samples (e.g., backed pieces represent < 2% of the Pinnacle Point 5-6 complete tools). This leads to the questions “Were MSA points used often?” and if so, “Why are they so rare in the archaeological record?” Here, we focus on points as projectiles and use an agent-based model to address these questions. The model combines experimental, archaeological, and ethnographic data to show the impact of hunting and carcass transport behavior on the distribution of projectile points and their characteristic edge damage. We run the model as part of the Paleoscape model, which explores the dynamics of hunting and gathering within the MSA ecology of South Africa. Results show that even when projectile points are used daily, most of them are lost on the landscape while hunting, and only ~1 in 78 points are transported back to camp. This suggests that the low number of projectile points found in archaeological sites does not mean those points were rarely used.

**Nakazawa**

## **Technological Choices of the Last Glacial Maximum foragers in Hokkaido, Northern Japan: Blade or Flake?**

Because of its formality and standardization in shape, size, and reduction sequences, presence of blades and blade-blank tools in Paleolithic archaeological record has been often regarded as the material representation of *Homo sapiens* and the emergence of “modern human behavior”. The premise that a shift from flake to blade technologies was substantially coupled with biological and behavioral changes from archaic to modern has been revised by temporal and geographic variability in the Paleolithic record in Europe and southwestern Asia (e.g., Hublin 2015). Even though the paleontological evidence is scarce, presence of blades has been long considered as the critical trait of Upper (Late) Paleolithic and *Homo sapiens* in northeastern Asia, but initial appearances of blades in archaeological record also vary depending on the scale of study regions. Earlier blade technology is found from continental parts of northeastern Asia notably in eastern Siberia, Mongolia, northwestern China, Korea, as well as from southern

islands of Japan (e.g., Honshu, Kyushu) at least by the late Marine Isotope Stage 3, ca. 38–30 ka (e.g., Bar-Yosef and Wang 2012; Lee et al., 2016; Nakazawa 2018), but appeared late in some regions. The present paper addresses the question of why blade technology appeared late with flake technology in some regional archaeological record of northeastern Asia where presence of blade technology not necessarily represent demic expansion of foragers, through a comparison of blade-dominant and flake-dominant assemblages co-occurred at small spatial scale that multiple groups of foragers could have shared to exploit resource in a given landscape. Study materials are from assemblages securely dated (~27–25,000 cal. BP) to the Last Glacial Maximum (LGM) in Hokkaido (northernmost island of Japan) where blades and blade-based tools first emerged during the LGM. Results will give implications for technological choices among foragers survived at the periphery of their dispersal routes.

## **O'Connell and Allen**

### **The recently reported 65,000-year age estimate for Sahul colonization is unreliable, and why that matters**

In 2017 Clarkson and colleagues published a minimum age estimate of 65,000 years (65 ka) for Madjedbebe (formerly Malakunanja II), an archaeological site in northern Australia. In the two years since, this date has been widely and for the most part positively cited in the scientific literature, the press and even in public statements by representatives of the Australian government. If it were valid, it would represent a 30-40% extension of the well-supported estimate of 45-50 ka for initial human colonization of Sahul (Pleistocene Australia-New Guinea), an important benchmark in the Late Pleistocene history of anatomically modern *Homo sapiens* (AMH). It would also support models of AMH spread into East and Southeast Asia during MIS-4, possibly as early as MIS-5. However, detailed review of the stratigraphic record at Madjedbebe shows that the claimed association between archaeological remains and dated sediments is unreliable (O'Connell et al. 2018). The archaeological remains themselves appear to be relatively young, perhaps no older than mid-Holocene in age. We present a summary of the results of that review and discussions since it was published. The record from more than 40 Sahul archaeological sites with age estimates >40 ka offers no evidence other than the questionable claim about Madjedbebe for human occupation of Pleistocene Australia-New Guinea earlier than about 50 ka. This finding refocuses attention on the “single wave” model dispersal of AMH across Eurasia and into Near Oceania 45-50 ka.

## **Otarola-Castillo**

### **Dietary Portfolios - A Theoretical Development to Explain Hominin Foraging Behavior**

The successful survival, reproduction, and dispersal of our hominin ancestors was likely fueled by their flexible capacity to forage for nutrient-dense foods in diverse environments. Optimal Foraging Theory (OFT) provides a hypothesis driven framework for understanding hominin foraging strategies, particularly in the context of foraging returns and foraging risk. However, OFT can be limited because 1) models frequently focus on maximizing caloric returns of single food sources, even though hominins are omnivores with mixed diets, and 2) foraging risk studies do not often account for the variation surrounding expected returns of multiple resources. This is problematic, because hominin foraging behavior is undoubtedly influenced by the expected returns and risk of a “dietary portfolio” composed of multiple food resources. Here, I show that some commonly used OFT models underperform by not accounting for the expected returns and variance of multiple resources. Alternatively, I present a novel multivariable extension to OFT for investigating the expected foraging returns and foraging risk of dietary portfolios from modern and prehistoric foragers who “invest” in multiple food resources. The dietary portfolio concept is a new but simple theoretical development to continue to test hypotheses about the foraging behavior of our hominin ancestors. It is particularly useful under circumstances where foraging returns and foraging risk might have been variable.

**Paige et al.**

## **Age uncertainty of stone tool assemblages, and its effect on measuring rates of increases in technological complexity**

Stone tools are the only source of information available concerning changes in hominin technological behavior over the course of millions of years. Here we investigate the effect of uncertainty in ages of archaeological sites on our ability to identify changes in the rates at which technological complexity increased. First, we measure complexity in stone tool technology among 50 archaeological assemblages, spanning the 3.3 million-year-old tools from Lomekwi in Africa to those produced by aboriginal groups in Queensland, Australia in the 20th century. Then, we calculate the rates at which technological complexity increased. We find that through much of human evolution, complexity increased at a slow and steady rate until sometime after ~500,000 years ago when the pace of technological evolution increased sharply. Finally, we use simulated data sets to measure whether our observations are robust to uncertainty in the ages of assemblages. We find that uncertainty in the true age differences between sites leads to further uncertainty about the true pace of increases in complexity. Preliminary results also suggest a possible increase in rates associated with the beginning of the Acheulean ~1.8 mya. Nonetheless, consistent with our original analysis, we found that new levels of complexity were likely explored very slowly across much of hominin evolution, with new levels being explored very quickly only in recent hominin history.

**Pargeter et al.**

## **Knowledge vs. Know-how? Dissecting the foundations of stone knapping skill**

Skillful knapping requires both explicit, strategic knowledge (*connaissance*) and implicit, practical know-how (*savoir-faire*). Although much work in cognitive archaeology has focused on the former, researchers working from a perception-action perspective emphasize the latter. Controlled experiments comparing experts and novices show extensive knapping experience is required to predict and control flake shapes. However, the process of acquiring such abilities remains poorly known and their practical contribution to success with Paleolithic technologies largely untested. To address these issues, we conducted a flake prediction experiment as part of a multidisciplinary study of Late Acheulean handaxe-making skill acquisition involving twenty-six naïve subjects and up to 90 hours training over several months. After every 10hrs training subjects were asked to mark and attempt to detach 5 flake predictions (outline & point of percussion) from a flint core. We fit a multivariate logistical regression model to the data with flake outcome (success/fail) as our dependent variable and several measurement variables describing flake shape, size, and platform characteristics as predictors. The results show that flake success rates increase with training along a learning curve paralleling that for handaxe-making success in the same subject population. However, flake predictions consistently deviated from known fracture-mechanical relationships throughout training, despite the fact that empirically-derived predictors of flaking success (exterior platform angle and platform depth) in our sample match these expectations. We conclude that simple flake detachment is a challenging skill (stabilizing only after ~40hrs training) that is central to initial improvements in handaxe-making but surprisingly independent of accurate fracture mechanical intuitions. Such intuitions apparently take much longer to develop (>90hrs) but may be unnecessary for success at relatively forgiving Early Stone Age technologies. These results inform our understanding of the cognitive demands of ESA skill acquisition and provide a benchmark for the training times required to capture this process experimentally.

**Patania et al.**

## **The Geoarchaeological History of Kisesee II Rockshelter, Tanzania**

The Late Pleistocene record of eastern Africa is at the center of debates concerning the origins and diversification of early *Homo sapiens*. However, our understanding of the nature and timing of behavioral changes during this period is limited by a lack of geochronological controls. Kisesee II rockshelter contains a 6-meter-thick stratigraphic sequence spanning ~ 45,000 years, and records archaeological changes associated with the Middle and Later Stone Age. Renewed excavations in 2017 incorporated high-resolution recovery methods, landscape-survey, micromorphology, and OSL dating. Geological survey of adjacent sedimentary exposures suggests that Kisesee II previously overlooked a small, shallow lake. This now-extinct lake forms a part of the Masai Steppe where

migratory wild game roamed as recently as 50 years ago. Water runoff from the escarpment running E-W toward the Steppe causes intense soil erosion, carving deep (ca. 2–5 m) gullies adjacent to the rockshelter. Initial micromorphological analyses revealed at least three distinct depositional phases. From bottom to top: 1) compact ashy layers containing micritic calcite and fragments of heated bones, 2) loose humic sediments, incorporating soil and calcitic clasts, and 3) bioturbated and water-saturated clayey sediments. Shifts from a calcitic to clayey fine fraction indicate a major change in depositional environment between the lower and upper layers, dated by radiocarbon to ~18-22 ka, at or around the Last Glacial Maximum, paralleled by technological shifts that include the proliferation of backed microliths. Our analyses also pinpoint intrusive backfill from earlier excavations, revealing a complex depositional and post-depositional sedimentary record, the understanding of which is necessary to contextualize ongoing excavation and paleoenvironmental studies at Kisele II, which can provide a benchmark sequence of human behavioral evolution for eastern Africa.

## **Pearson et al.**

### **Amud 9, a partial Neandertal foot from late Mousterian of Israel**

The renewed excavations of Amud Cave in 1991-1994 furnished OSL and TL ages for the upper portions of Amud's Middle Paleolithic deposit. The dates center ~ 55 ka, very close in time to the inferred date of Neandertal interbreeding based on aDNA and slightly before the first appearance of Upper Paleolithic industries in the Levant. The excavations produced 14 new Neandertal specimens, including Amud 9, a partial right foot. The foot comprises portions of the distal tibia, talus, first metatarsal, first proximal phalanx, and a middle and distal phalanx of digit II-IV. The bones are fairly small and likely belonged to a female. The talus features a strongly projecting fibular articular facet in common with Neandertals, early modern humans from Skhul and Qafzeh, and many tali from Sima de los Huesos. Discriminant analysis of the talus shows that its nearest match lies among tali from Sima de los Huesos, a result primarily attributable to its moderately enlarged posterior trochlear articular breadth. The first metatarsal falls among Neandertals in discriminant space. The pedal phalanges are short and broad, like those of other Neandertals. The length of the first metatarsal and talus predict a female's stature of 160 - 166 cm. The width of talar trochlea predicts a body mass of 59.9 kg. Amud 9's overall size resembles Tabun C1. Given its close approximation in antiquity to the spread of modern humans, Amud 9's morphological affinities are of great interest. Amud 9 shows no unequivocal morphological trace of admixture with modern humans, although talar shapes of early modern humans from Skhul and Qafzeh resemble those of Neandertals. Nevertheless, the overall pedal morphology of Amud 9 closely resembles Neandertals, strengthening the impression of the relatively sudden nature of the break between Neandertals and modern humans in the Levant.

## **Pelissero et al.**

### **Rethinking the Laetoli Hominin Trackmakers in Light of New Prints at Site S**

The discovery of the 3.66 Ma hominin footprints at Site G in Laetoli, Tanzania was one of the most important advances in the study of human origins, particularly the evolution of upright posture. Preserving some of the earliest definitive evidence for upright bipedal locomotion in hominins, the prints have been tentatively attributed to *Australopithecus afarensis*, the previously only known Pliocene hominin from Laetoli. However, the nature of the trackmakers' locomotor repertoire has been the subject of argument for decades. The recent discovery of additional hominin footprints at Site S, roughly 500 meters away from Site G, has reignited fresh debates about the taxonomic assignment of the trackmakers and their locomotor capabilities. This discovery has also provided a critical comparative data set with which various hypotheses regarding Pliocene ichnotaxonomy and locomotor diversity can be tested. While the two trackways themselves are contemporaneous and share similar depositional history, there is noticeable size differences between the two groups of trackmakers. Considering this, we conducted a comparative analysis on the gait patterns and morphological characteristics of the prints between Site S and Site G utilizing digital photogrammetry and direct measurements from the trackways. While there are affinities between the two sets of prints, there are also striking differences, most notably the footprint morphology of the large S-1 individual, which falls well within normal ranges of modern humans, to the exclusion of the G-1 and G-2/3 tracks. Contextualized within recent fossil discoveries that have expanded our knowledge of hominin diversity at Laetoli in the Pliocene, these differences could suggest that the Laetoli footprints were created by a singular species with significant sexual dimorphism or by two separate taxa coexisting at the site.



**Plummer et al.**

## **Reconstructing Middle Stone Age Paleoclimates in the Lowlands of NW Ethiopia from Isotopic Indicators in Ancient Enamel**

Understanding human responses to climate and resource availability is critical for framing the context for modern human adaptations during the Middle Stone Age (MSA). We present data from SM1, an MSA site located along the Shinka River, a trunk tributary of the Blue Nile River in the lowlands of NW Ethiopia. Today, the river runs bank full during the short wet season and, after flows cease, is reduced to isolated water holes during the dry season. The river is the central water source for modern mammals and was also likely the case for ancient mammals. High evaporation rates of water in isolated bodies such as water holes theoretically produce increasingly higher concentrations of  $\delta^{18}\text{O}$  as the dry season progresses. Mammals drinking from these sources should preserve isotopic markers of seasonal variation in the tooth enamel as the dentition develops. We tested this idea by collecting river water on a weekly basis for a period of nearly 10 years. Enamel was sampled from modern mammals, and together this modern setting served as a proxy to evaluate isotopic values from fossil mammal enamel. Modern and fossil mammal teeth were serially sampled for  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  to evaluate bio-available  $\text{H}_2\text{O}$  and  $\text{C}_3$  to  $\text{C}_4$  diets and, indirectly, vegetative cover. Our results indicate that the degree of seasonality during the SM1 occupation was similar to today's seasonal climate, offering support for reconstructions drawn from other data that these MSA humans were adapted to highly seasonal climates and likely occupied the site during the dry season.

**Pobiner and Peters**

## **Taphonomic drivers of Early Stone Age butchery mark patterns**

Thompson et al. (in press) recently suggested that the "human predatory pattern", the regular exploitation of large animal resources, began with an emphasis on percussion-based scavenging of inside-bone nutrients independently of flaked stone tool use. To begin to evaluate this proposition, we compiled a list of all African archaeological sites dating to between ~3.4 and ~1.4 million years ago with traces of butchery (cut and percussion) marks on fauna and/or presence of lithics. In exploring these data for patterns of change in both the number and proportion of cut and percussion marked bones and number of lithics over time, we do not see a strong correlation between number of butchery marks and number of lithics, in support of Thompson et al.'s suggestion. However, taphonomic variables - including the quality of bone surface preservation and number of bones present - rather than variables related to butchery behaviors may be driving some patterns of butchery mark incidence across time and space. We will outline several issues relating to a lack of standardization of data collection and reporting that make direct comparisons between sites difficult. We join Thompson and colleagues (and others) in calling for research focus on fieldwork in Pliocene deposits as well as laboratory-based study of fossil collections previously considered to be outside the time range of the earliest hominin butchery.

**Pop et al.**

## **Evaluating landscape knowledge and lithic resource selection at the French Middle Palaeolithic site of Bau de l'Aubesier**

We report on the application of a novel approach to exploring the degree of landscape knowledge and the nature of decision-making processes reflected in the utilization of stone resources in the French Middle Palaeolithic. Specifically, we use data from Bau de l'Aubesier to explore the reasons why a majority of the 350 sources catalogued in the region surrounding the site appear not to have been utilized, including several located near Bau and yielding high-quality materials. Indeed, most of the nearly 16,000 provenanced lithics at Bau appear to have been collected from sources requiring considerable travel time (1+ hours) and suggest a NE-SW procurement corridor. We depart from previous efforts in focusing on the spatial relationships between sources as an explanatory variable, operationalized in terms of minimum travel times. Using GIS and a generalized linear model of resource selection derived from the Bau assemblages, we compute individual source utilization probabilities for each possible landscape location throughout the region (~1,200  $\text{km}^2$  at 90m resolution), factoring in the intrinsic characteristics (e.g. quality) of, and time required to reach, each source on the way to the Bau. We find that in most cases seemingly viable sources were likely not exploited simply because the minimum cost path leading back to Bau passes through, or requires only minimal deviations to reach, higher quality sources. More generally, we find that throughout the entire region a cost/benefit analysis of competing sources favours those

from areas known to have been utilized. Virtually all the available information on lithic procurement at Bau is consistent with a model of relatively uniform landscape utilization premised on detailed knowledge of a very large area, an ability to accurately estimate travel times between all locations, and a pragmatic strategy of stone resource exploitation based on minimizing costs (travel and search times) and maximizing utility.

**Popescu et al.**

## **Locational Modeling of Upper Paleolithic Settlement in Northeastern Romania**

GIS based locational analysis has been used for the past several decades to help identify potentially archaeologically sensitive areas and target more effective survey strategies, especially for cultural resource management. However, it has been less widely used for regional scale research on Paleolithic settlement. Here we present a locational analysis to predict likely Upper Paleolithic site location in Ceahlău Basin, northeastern Romania, using a Grass GIS based approach grounded on regional terrain characteristics and theory regarding hunter-gatherers site locations. We especially seek to identify geographic areas with probable higher concentration of sites, which is especially important in this region that has suffered site destruction due to erosion and anthropogenic activity. We base our locational algorithm on characteristics derived from the ethnographic and archaeological literature, and consider that the following are important determinants of hunter-gatherers' settlement systems: 1) distance from streams or other waterbodies, 2) cumulative viewshed, 3) terrain features, and 4) elevation. We combine these key elements in analytical maps in Grass GIS to develop a predictive model, and then will test our model with a set of known sites in order to evaluate its effectiveness. We will also create a map of potential erosion, calculated from Revised Universal Soil Loss (RUSLE) coefficients to assess those areas of the predictive model that are at greatest risk of damage or loss to better prioritize archaeological investigation.

**Porter and Brooks**

## **New Data on the Early Stone Age of the Semliki River (DR Congo)**

Few Early Stone Age (ESA) assemblages in clear stratigraphic context are known from the Western Rift and fewer still have any associated chronological information. Here we describe Early Stone Age materials and fauna stratified 7m below the Middle Stone Age horizon at Katanda-2, as well as excavated younger Acheulean materials from Kasaka-2, ~8 km. to the north-northeast. The Paleolithic sites of the Upper Semliki Valley in the Western Rift were originally explored by J. de Heinzelin and others in the 1950s. He described ESA materials from three localities: Katanda, Kasaka, and Kanyatsi. These sites span ~20km along the northern shore of Lake Edward and the Upper Semliki River. Discovery of what is now regarded as an early hominin molar at the Semliki Valley site of Ishango (Crevecoeur et al., 2014) indicates the importance of a second look at the "Oldowan" tools at Senga-5a between Katanda and Kasaka. While these were Oldowan in character and were in association with extinct mammalian fauna, their stratigraphic integrity was questioned. As part of the Semliki Research Expedition (1985-1990), A. Brooks, in collaboration with J. de Heinzelin, J. Verniers, D. Helgren, and K. Stewart, renewed excavations at the original Katanda locality (now KT2) and at Kasaka (now KS2). These new excavations recovered additional ESA materials from the Semliki beds at KT2 in association with extinct mammalian fauna and Acheulean materials from the Kasaka Upper Terrace at KS2. The KT2 ESA assemblage contains one partial biface, fragments with bifacial retouch, several polyhedrons, and many scraping tools. All artifacts are made on quartz or quartzite. The closest affinities of the KT2 ESA materials are with "Developed Oldowan" assemblages in East Africa. The assemblage and associated faunal remains suggest an early Middle Pleistocene or older age. The younger KS2 Acheulean assemblage contains large well-made bifaces and multiple spheroids.

**Porter et al.**

## **A Lithic Behavioral Approach to Cultural Transmission Hypotheses across the Late Mousterian, Châtelperronian, and Protoaurignacian in Western Europe**

When reconstructing past social relationships, we must not only ask if groups of humans interacted, but also how. The behavioral approach to cultural transmission, or BACT (Tostevin, in press), aims to do just this. For the first time we apply this method to western Europe, where Neanderthals and anatomically modern humans (AMHs) may have overlapped both spatially and temporally just prior to Neanderthal extinction. To complicate matters, late Neanderthal technology shares many traits with industries associated with AMHs. Did Neanderthals develop these technologies independently, or were they influenced by incoming groups? Our analysis incorporates data from five lithic assemblages: La Rochette couche 7 (MTA), Abri Peyrony layer L-3A (MTA), Roc-de-Combe couche 8, Les Cottés US 6 (Châtelperronian) and Les Cottés US 4inf (Protoaurignacian). We follow the schema of Tostevin (2007), which places assemblages in the hypothesized role of substrate (the “ancestral” technology), acculturator (the influencing technology), and product (the result of the influence of the acculturator on the substrate). Lithic attributes are assessed for their level of similarity between assemblages. This produces a signal of independence (no similarity), continuity (similarity between all three assemblages or the substrate and product), or acculturation (similarity between the product and acculturator, but not the substrate). These signals are summed into analytical domains corresponding to early and late phases of the production process (blank vs. toolkit creation), which are accessible at different levels of social intimacy (in domestic spaces vs. on the pathways of the landscape). We can thus infer a higher degree of social intimacy between groups if we find an acculturation signal in both early and late stages of lithic production. With this work we aim to shed light on the “Châtelperronian conundrum” (Roussel et al. 2016), as well as the nature and extent of Neanderthal and AMH relations on a broader scale.

**Quinn**

## **Isotopic equifinality and rethinking the diet of *Australopithecus anamensis***

*Australopithecus anamensis* shows ostensibly conflicting evidence for diet via enamel stable carbon isotopes, dentognathic morphology, and dental microwear. *A. anamensis* has comparable enamel carbonate  $\delta^{13}\text{C}$  values to *Ardipithecus ramidus*, and both have been characterized as  $\text{C}_3$  feeders in open woodland habitats similar to “savanna” chimps. Unlike *Ar. ramidus* and “savanna” chimps, *A. anamensis* shows a derived dentognathic morphology for tough foods and a dental microwear pattern similar to the  $\text{C}_3$ - $\text{C}_4$ -mixed-feeding *A. afarensis*. In this study I utilize Pliocene pedogenic carbonate and faunal enamel  $\delta^{13}\text{C}$  values from the Kanapoi, Mursi, Nachukui and Koobi Fora formations to determine the  $\delta^{13}\text{C}$  range in vegetation available to *A. anamensis* in the Omo-Turkana Basin. Faunal  $\delta^{13}\text{C}$  values demonstrate the potential for canopy-driven,  $^{13}\text{C}$ -depleted  $\text{C}_3$  ground vegetation in the riparian forests/woodlands along the Proto-Omo River. I recalculate *A. anamensis*' percent  $\text{C}_4$  diet by slightly increasing the  $\delta^{13}\text{C}$  diet-tissue spacing based on published primate/mammalian data and by decreasing the average  $\text{C}_3$  plant end member  $\delta^{13}\text{C}$  value. The proposed combination of resources results in a substantially larger proportion of  $\text{C}_4$  resources (18-36%) than previously thought (0-10%). Informed by Pliocene environments in the Omo-Turkana Basin and the potential for isotopic equifinality, this scenario reconciles the contradictory diet proxies of *A. anamensis*.

**Raja et al.**

## **Deciphering sediments in archaeological context: inferences on the paleoenvironmental changes and the site formation processes in the Middle and Late Stone Age, Txina-Txina, Massingir (Mozambique)**

In the framework of the project “Middle and Late Stone Archaeology in Machampane Valley, Limpopo River basin, southern Mozambique”, the sediment record in archaeological context of the Middle and Late Stone Age from Txina-Txina site (Massingir,

Southern Mozambique) was collected and analyzed. The analysis allowed us to decipher the history of the local paleoenvironmental changes as well as the site formation processes. Such information is highly important to better understand the past human behavior. For this study, a set of methodological procedures were applied, namely: (1) analysis of local geology and geomorphology (2) collection of sediment samples in a section on the wall of Txina-Txina site, as well as in test pits; (3) textural morphometric analysis of sediments ; and (4) geochemical analysis of sediments. Additionally, the number and weight of lithics was measured on the test pits. These data were combined with radiocarbon dating. Our results demonstrated that next to the hill slope there are colluvial sediments with angular boulders at the base of the sequence. These sediments were overlaid by a conglomerate covered by fine sediments episodically interrupted by gravel layers. The presence of a conglomerate and round gravel layers indicates that there were high energy events along the river. According to the radiocarbon dating, these gravel layers were deposited in wet periods that occurred before 29000 and after 14000 years ago, during the African Humid Period. Although our interpretation is that the fine sediments have mostly a colluvial origin, more analysis will be carried out to confirm this hypothesis. The concentration of lithic material in Txina-Txina site seems to be associated with the drier periods.

**Ranhorn et al.**

## **New Archaeological Evidence from the Middle Stone Age of East Turkana**

The Omo-Turkana Basin boasts an extended and detailed Pleistocene chronological context, including some of the earliest known modern human remains (1). The population structure and interactions of these early modern human communities, however, remains poorly characterized, necessitating the reconstruction of human behavioral patterns in this region at a landscape-scale. Since 2013, the Koobi Fora Middle Stone Age Project conducted extensive landscape surveys and excavations at multiple localities superjacent to the Koobi Fora Formation, focused on Late Pleistocene sediments that extend across 60 km east of Lake Turkana. Through continued geological and archaeological investigations, including a careful re-evaluation of the Guomde Formation (2), we are building a multi-scalar paleo-lake model reconstruction of Late Pleistocene human behavior in Turkana. This provides an unprecedented view into the ecosystems and behaviors of communities that lived in this part of East Africa during a time when early modern human populations migrated throughout the African continent, and ultimately, across the globe. We present results from Gajj17, an artifact-bearing locality in primary context, which we dated with optically stimulated luminescence (OSL) to 70-30 ka. Stone artifacts within this deposit include convergent Levallois points on volcanic rocks (basalt and ignimbrite) and small retouched tools, predominantly on cryptocrystalline silicas. Aquatic taxa, namely fish and hippopotamus, dominate the faunal assemblage. Micromorphological evidence implies that Gajj17 formed as an ancient lakeside sand dune. A capping caliche deposit buffered this site from subsequent Holocene high lakestands. Gajj17, in combination with other Middle Stone Age localities discovered by our team, underscores the need for future landscape geoarchaeology research into the Late Pleistocene of East Turkana.

**Reed**

## **Origins: a paleoanthropology database**

Fundamental questions about human origins, such as the biogeographic distribution of hominin taxa through time and space, rates and timing of species origination and extinction, the co-occurrence of hominin taxa, and the co-occurrence of hominin adaptations with climatic and geological events, all require integration of heterogeneous data across fossil sites. Compiling the data to address these types of questions from original sources is laborious and error prone, because, as yet there is no comprehensive catalog (digital or otherwise) of the hominin fossil record nor connections to other relevant external data sources on climate and geology. The Origins Project is an effort to establish a comprehensive database of hominin fossil and archaeological occurrences by integrating data on hominin fossil specimens, archeological occurrences, taxonomic designations, geospatial location, geological context, dates, anatomical descriptions, measurements, images and bibliographic references from publicly available online resources. Data on 3000+ fossil and archaeological occurrences were imported into the Origins Database, hosted at Paleo Core (<http://paleocore.org>), an open-source, geospatial data management platform, and aligned to the Paleo Core data standard. These data were cleaned and validated using Python scripts, then linked to related data on temporal periods, taxonomy and geological context from external data sources using application programming interfaces (APIs) and linked data protocols. With these data we are able to visualize the distribution of fossil and archaeological occurrences in four dimensions, immediately query for type fossils for all taxa, calculate first occurrence and last occurrence datums for taxa, examine relative abundances of taxa in different time

intervals as well as trends in anatomical element abundances. The Origins Database is a stepping stone to developing a comprehensive, paleoanthropology database that can facilitate integrative research on human origins.

## **Reeves and Braun**

### **Time-Averaging, Hominin Foraging Strategies, and Assemblage formation: how do we draw behavioral inferences from the Earlier Stone Age record?**

Reconstructions of early hominin foraging strategies play an important role in understanding the ecological context of hominin behavioral evolution. Such studies often focus on the formation dense accumulations of fossils and stone artifacts. These accumulations of artifacts are often considered to reflect centers of hominin behavior. However, the relationship between artifact density and the intensity of space use is not necessarily linear. The time-averaged nature of the Earlier Stone Age record forces archaeologists to understand behavioral patterns that have a time depth beyond an ethnographic understanding of space use. Developing inferences of behavior for specific localities based on assemblages that represent tens of thousands of years remains problematic. It is difficult to investigate how hominin foraging and stone tool discard behaviors structuring the archaeological record with Early Stone Age assemblages represent thousands of years of time. Here we introduce a probabilistic approach for drawing behavioral inferences from time-averaged assemblages. We use agent-based modeling to generate time-averaged lithic assemblages under various conditions of hominin land-use. We analyze these simulated assemblages using measures of stone tool transport, to determine how different land use strategies influence the formation of the archaeological record. The results of the model show that some measures of stone tool transport reflect patterns of landscape use regardless of palimpsest nature of the record. This provides useful expectations to interpret empirical archaeological data from a series of dense sites from the Koobi Fora Formation in northern Kenya. Inter-site differences in specific measures of stone tool transport indicate that patterns of behavior are not necessarily reflected in the densities of artifacts at specific sites. These differences suggest that the formation of the ESA record is influenced by paleogeographic context. These promising results emphasize the efficacy of this approach for understanding time-averaged data-sets.

## **Rmoutilova et al.**

### **Revisiting the sex of Neandertal coxal bones using a probabilistic approach**

Sex attribution of fossil specimens is a complicated but essential question in paleoanthropology. Neandertals are an extinct taxon with very good fossil record which enabled researchers to pose questions about sex differences in physical constitution or locomotion. As Neandertals were highly encephalized hominins, it is assumed that they also possessed pelvic adaptations to birth and thus the sex of Neandertal specimens was apart from robusticity differences assessed based on modern pelvic criteria. However, despite this fact, no standard sex estimation method providing probability of an estimate was used for this purpose. Therefore, we applied two (visual and morphometric) sex estimation methods from the coxal bone (Bruzek, 2002; Bruzek and Murail, 2006; Bruzek et al., 2017; Santos et al., in review) that both provide posterior probabilities for various combinations of variables. Original specimens, virtual 3D models and published data and descriptions for 12 Neandertal individuals were used to assess sex traits or acquire measurements. Due to preservation reasons and special morphology in the pubic region, traits from the anterior pelvic region were excluded. With the probability threshold of 90%, 8 specimens were sexed by both methods (within them only the specimen from Grotte du Prince had contradictory results) and for other 4 specimens sex was provided by only one method either because of low posterior probability or unavailability of data. When considered only the unambiguous cases (11), 9 of them were congruent and one incongruent (Amud 1) with the most frequent or genetically diagnosed sex attribution found in the literature. Despite generally considered indeterminate, the remaining specimen (Regourdou 1) could be sexed in our study thanks to the previous reconstruction of its right coxal bone. This study shows a potential efficiency of the application of modern sex estimation methods on the Neandertal sample.

**Rowe**

## **Identification of microbial modifications on postmortem bone**

Identification of bone surface modifications can lead researchers to an accurate interpretation of the taphonomic forces which have influenced peri and post mortem remains. Microbes have been shown to destroy living bone, while producing unique morphology, and have also been shown to degrade and influence the preservation of post mortem bone. However, the micromorphology of microbial modifications on post mortem bone has never been described in detail. Recently, I examined bone that was collected nine months post depositional and using scanning electron microscopy was able to identify the same diagnostic microbial modifications that were found on living bone. This identification is important for comparison to modifications found on archaeological bone that is suggested as retaining evidence of microbial activity, such as the faunal remains from the FLK-Zinj site at Olduvai Gorge. Applying these data to modifications at archaeological sites will help parse those taphonomic processes created by hominins and carnivores from those made by microbes, which will assist researchers in constructing stronger theories regarding behaviors that led to the creation of specific faunal assemblages.

**Schoville et al.**

## **Early Middle Stone Age Technology on the edge of the southern Kalahari at Witberg 1, Tswalu Kalahari Reserve, South Africa**

Understanding the development of Middle Stone Age (MSA) technologies is complicated by at least two issues. First, few sites preserve sediments in the crucial time period when fossil and genetic evidence point to the origins of *Homo sapiens*. Second, large bifacial tools sometimes found with the earliest MSA technologies may be linked to commingled deposits rather than documenting transitional industries. Witberg 1 (WB1) is a newly identified Middle Pleistocene open-air calcrete pan located on the margin of the southern Kalahari Basin in the Tswalu Kalahari Reserve. Artifacts visible in profile due to quarrying the calcrete for road building were mentioned by Beaumont and Bednarik (2015), but otherwise no prior archaeological excavation or recording has occurred at WB1. In 2018, we began excavations and total station piece plotted a dense lithic artifact horizon (n=578) comprising prepared cores, faceted points, and large blades, consistent with early MSA technology at other sites, but so far lacking evidence of an Acheulean technological component. OSL and U-series dating provide a clear timeline of deposition comparable to early MSA deposits at Kathu Pan 1 (Porat et al., 2010), Florisbad (Kuman et al., 1999) and Olorgesailie (Deino et al., 2018). A fabric analysis of artifact orientation and dip indicates little post-depositional movement or realignment, and the limited vertical distribution of artifacts suggest an intact and dense concentration of occupation. The location of WB1 in what is today a semi-arid environment points to adaptive behavioral flexibility during the Middle Pleistocene. WB1 provides new information on the timing and location of MSA technological origins, further refining the dynamic relationship between archaeological and biological changes associated with a potential pan-African origin (Hublin et al., 2017) of the modern human lineage.

**Semaw et al.**

## **The Early Acheulian archaeology from Gona, Ethiopia: technology and implications on hominin diet**

The Gona archaeological sites preserve continuous deposits spanning the past 2.6 million years (with minor gaps), providing an opportunity for investigating the emergence and evolution of the Acheulian. The Gona team has been conducting investigations in deposits estimated between 2.0-1.5 Ma in order to explore the timing and background of the emergence of the Acheulian. We have documented several new archaeological localities estimated to ~ 1.5 Ma and older, including several localities with Acheulian tool types, and research is in progress to date these sites precisely with both radiometric and non-radiometric dating techniques. Preliminary studies show that compared to the makers of the preceding Oldowan, *H. erectus* was engaged in a different kind of raw material selectivity, based mainly on large size, but also targeting materials with good flaking quality where accessible. Acheulian handaxes have been suggested to be effective butchery tools, but more extensive exploitation of animal carcasses has been documented at earlier Oldowan sites than at Acheulian sites at Gona. The recovery of more abundant cutmarked bones with the Oldowan could, in part, be explained by a prior intensive research focus on the earliest Oldowan sites, and possible preservation biases. However, the rarity of large animal fossils with evidence of butchery for the Early Acheulian at Gona appears to be

remarkable, especially in light of one of the main supposed functions of handaxes. The Acheulian is technologically drastically different from the Oldowan, but the ecological background and the adaptive significance of this emergent stone technology in the life of *H. erectus* has yet to be fully investigated and understood. Further, Oldowan-type core/flake artifacts co-existed with the Acheulian, but distinguishing the functional role of the two artifact modes in the life of *H. erectus* remains unclear.

**Stahlschmidt et al.**

## **Burning signature in tortoise bones produced during a recent wildfire at Cape Point: implications for archaeological interpretations of burning signatures in bones**

High heating temperatures recorded in animal bones from Paleolithic sites have often been interpreted as evidence for human control of fire. But, in fact, tree-crown fires, volcanic eruptions, and lightning strikes can also produce high temperatures. Gowlett et al. (2017) measured temperatures occurring in several wildfires in Eastern and Southern Africa and observed what effect wildfires can have on carcasses placed in their way. While vegetation and the presence of dung played a big role in the intensity and duration of the fires, Gowlett et al. (2017) observed that wildfires can reach similar hot temperatures to camp fires, between 300 °C and 800 °C. However, temperatures were measured with thermostats and only macroscopic alterations of the cadavers were observed. It remained open what burning signature would actually be left in the bones, which would be the material evidence of the burning in the archaeological record. We here present an investigation of burning temperatures for tortoise bones, which were burnt during a wildfire at Cape Point, South Africa, in 2015. We have samples from tortoises that died during the wildfire as well previously deceased tortoises skeletons exposed on the landscape. We performed Fourier-Transform Infrared (FTIR) Spectroscopy to investigate the burning signature of the bones following spectra interpretations by Weiner and Bar-Yosef (1990), Surovell and Stiner (2001), Schiegl et al. (2003) and Mentzer (2014). Our FTIR analyses show that the wildfire at Cape Point mainly affected the surface of the bones and only rarely did bones burn through. The inferred burning temperature signal went up to 700 °C for the bones from both the recently deceased and the old landscape tortoises, but the landscape specimens show a slightly increased temperature signal. Our analysis confirms Gowlett et al.'s (2017) conclusion that temperature in itself is a poor deciding factor between natural and camp fires.

**Straus and Gonzalez-Morales**

## **Analyses of the 'Red Lady' Magdalenian burial in El Mirón Cave (Cantabria, Spain)**

In 2012, the authors presented a preliminary report on the discovery of a human burial in Lower Magdalenian context in El Mirón Cave (Cantabria, Spain) at the Paleoanthropology Society Meeting. Since then, additional remains were uncovered and many biological and archeological analyses have been conducted. Originally interpreted as a secondary burial, the "Red Lady" is now understood to be a disturbed primary interment from which certain major elements (cranium, most long bones) had been removed, possibly as part of rituals that did not end with the original burial. Still-ongoing multidisciplinary analyses of this rare burial (unique for the Magdalenian of the Iberian Peninsula, but similar to penecontemporaneous ones in France) include osteological and dental studies of the remains to determine age, sex, physical and health status; dental residue studies on (mixed meat, seafood and plant) diet and (absent) infectious pathogens; determination of ancient DNA. In addition, there have been archeological studies of the grave, artifactual and faunal contents of its infilling; its proximity to rock art engravings and pigment staining possibly marking the grave, mineralogical determination of the exact, non-local sources of the specially-prepared hematite ochre used to stain the clothing, body and/or bones of the deceased as well as the adjacent block and cave wall. It is apparent that this robust, apparently healthy 35-40-year-old female was given rare, very special treatment after death that involved considerable investment on the part of the social group of which she had been an important member. The "Red Lady" of El Mirón joins the adult women buried in the French Magdalenian sites of Saint-Germain-la-Rivière, Chancelade, Cap-Blanc and Lafaye; only one other buried Magdalenian-age skeleton whose sex could be determined (Lauferie-Basse) was an adult male according to D. Henry-Gambier. Either this is a coincidence or the presumed special status of "men the hunters" is overrated.

**Szuster et al.**

## **A novel approach to reconstructing the forearm length and brachial index of *Australopithecus afarensis* specimen A.L. 288-1 (“Lucy”)**

Although A.L. 288-1 (“Lucy”) exhibits ape-like humerofemoral proportions, the brachial proportions have remained unresolved because pieces of the shaft are missing from both right and left radius and ulna. Prior regression-based approaches to estimate bone length have produced both “ape-like” and “human-like” forelimb proportions. The aim of this study was to estimate the brachial index (radius length / humerus length X 100) of A.L. 288-1 using 3D digital polygon models to reconstruct forearm length with a complete ulnar specimen of a separate individual (A.L. 438) used as a guide. The missing section of the right ulnar diaphysis was reconstructed by scaling A.L. 438 and matching homologous bony landmarks on the epiphyses. Maximum length of the fragmented right radius was determined by aligning proximal and distal radioulnar joints with corresponding surfaces on the reconstructed ulna. The reconstructed ulna measures 160.6 mm and maximum radius length measures 146.0 mm. With a humerus length of 236.8 mm, the brachial index for A.L. 288-1 is calculated as 62. The error associated with this method (e.g., from allometric scaling effects and inaccuracies in the surface-matching approach) was modeled using a highly sexually-dimorphic taxon (*Gorilla gorilla*). Although error may reach as high as 20% in the bone-length estimates, bracketing the reconstructed radius lengths for A.L. 288-1 still returns values that fall well within the range of brachial indices for *Homo sapiens* or the low end of the *Gorilla* range. A *Pan*-like long forelimb is highly unlikely. Assuming a long forearm is primitive for hominins, *A. afarensis* was derived in having a short distal forelimb. Furthermore, given the high brachial index of *A. sediba* and the Bouri material (BOU-VP 12/1), A.L. 288-1 demonstrates considerable limb-proportion variability among early hominins. This has important implications for understanding *A. afarensis* locomotor behavior and the evolution of the hominin upper limb.

**Thompson et al.**

## **First reconstructions of Late Pleistocene paleoenvironments and hunter-gatherer behavior in the Zambezian miombo woodland zone of Malawi**

Little is known about Middle and Later Stone Age adaptations in the Zambezian Phytogeographic Zone (ZPGZ), which stretches across south-central Africa from Angola to Mozambique. During the last glacial, when the Intertropical Convergence Zone and North Africa were dry the ZPGZ remained humid, and may have been an important population refugium. Numerous archaeological sites demonstrate that the region played a long and significant role in Late Pleistocene human evolution, but most are poorly dated or have poor faunal preservation. New work in northern Malawi has identified Late Pleistocene rock shelter sites with good organic preservation. Together, three of these sites span a time from >30 ka to ~8 ka, and contain the remains of at least 9 Later Stone Age hunter-gatherers. We present direct ages for these remains that place them at the Pleistocene-Holocene boundary, and offer a rare multi-site examination of mortuary treatment and Later Stone Age material culture in the ZPGZ. We also present the first detailed data that show paleoenvironmental change and human response in the region. At the end of the Pleistocene, grassland-adapted fauna such as ostriches, equids, and large grazing ungulates gave way to small-bodied, woodland-adapted species, potentially representing the first appearance of the ZPGZ in its modern manifestation. This transition is 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 stone tool assemblages are entirely manufactured on quartz, and this has important implications for identifying the transition from the Middle to Later Stone Age, which occurs by 26 ka farther north in Malawi. These new data give unprecedented insight into the relationships between Pleistocene paleoenvironments and human behavior in an important, but understudied region of Africa.

**Tolley et al.**

## **A Quantitative Assessment of Percussion Marks at HWK EE, Olduvai Gorge, Tanzania**

The presence of percussion marks on faunal remains demonstrates that hominins used a hammerstone-on-anvil technique to break animal bones with the intention of extracting and consuming fat-rich bone marrow. The analysis of such marks holds important



implications for the evolution of stone tool technologies, as well as hominin encephalization, which roughly coincide with the appearance of percussion marks in the archaeological record. Zooarchaeologists have typically used low-power hand lenses or 2D microscopic techniques to discern percussion marks on faunal remains, but these methods are difficult to reproduce between researchers and are limited in the behavioral inferences they can produce. The use of high-resolution 3-D scanning has shown potential to enhance interpretations of bone surface modifications, including percussion marks. Here, we use a new approach that applies high-resolution 3-D scanning to identify the unique characteristics and quantify the micromorphology of percussion marks at the 1.7 million-year-old HWK EE site, Olduvai Gorge, Tanzania. Molds were taken of previously-identified percussion marks on bones excavated at HWK EE. 3-D reconstructions of these marks were produced using a Sensofar S neox non-contact 3-D surface profiler, which were processed and measured using SensoMAP, an adaptation of Digital Surf's Mountains software. Measurements recorded from the 3-D models include volume, surface area, maximum depth, width, and length. Additional measurements collected from 2D cross-sectional profiles include cross-sectional area, width, depth, and roughness. Quadratic discriminant analysis of these measurements, as well as the measurements from known samples of bone surface modifications, demonstrates a distinction between the micromorphology of percussion marks and the micromorphology of tooth marks, cut marks, and trample marks. When applied to the fossil record, these quantitative measurements allow percussion marks to be identified and analyzed with greater accuracy, thus providing a better understanding of hominin behavior and evolution during the Early Stone Age.

**Tostevin et al.**

## **Macro- and Micro-archaeology in the Middle Danube: the role of Tvarožná X in understanding the Middle to Upper Paleolithic transition**

The behavioral variability across the Middle to Upper Paleolithic (MP-UP) transition in Central Europe has long been recognized as important for understanding the biological transition between Neanderthals and modern *Homo sapiens*. Yet the exact meaning of this variability (as evidence of continuity, acculturation, or replacement) has been obscured by the apparent complexity of the patterning of lithic behaviors which were traditionally used to define the MP-UP industrial types. A number of important assemblages do not fit the current systematics and yet it is difficult to test hypotheses to explain this variation without independent contextual data. Additionally, almost all of these assemblages come from bone-poor open-air sites. This prevents the correlation of lithic data with faunal exploitation patterns for determining site function for individual assemblages (e.g. Delagnes & Rendu 2011). The present study evaluates a multi-year project at an Early Upper Paleolithic open-air site in the Middle Danube Basin, Tvarožná X (Czech Republic), that applied microarchaeology (on-site FTIR, micromorphology, phytoliths, & geochemistry) to test for the original presence vs. absence of taphonomically-invisible behaviors that would inform on site function, such as butchery, hearth creation, or plant processing. Originally developed for caves, several of these techniques showed added complications when applied to this open-air site first introduced by Škrdla et al. (2009). This presentation explores these practical lessons but also applies macroartifactual variables (malacology, raw material unit analysis, core reduction intensity, Clarkson & Kuhn tool reduction indices, temporal analysis through refitting, and behavioral reconstruction of operational sequences) and radiometric dating (AMS, TL, and OSL) to investigate the variation represented by Tvarožná X. By considering 10 other individual assemblages according to these variables, the project provides a broadening of our view of the MP-UP transition beyond industrial type labels.

**Uy et al.**

## **What can the pelvis tell us about gut size?**

The gastrointestinal tract or "gut" is supported by the bony pelvis below it, suggesting that the pelvis and gut are morphologically linked—something that has been speculated by paleoanthropologists for a long time. Among primates, capuchins converge with humans in relative gut size and gut morphology. Here we explore the bony pelvis and its relationship with gut volume in both species. Our approach utilizes intestinal volume measured in vivo from abdominal CT scans of living humans (*Homo sapiens*) and whole-body CT scans of tufted capuchins (*Cebus apella*). The results show that a significant relationship between bi-iliac breadth and gut volume in humans, but not in capuchins. 3D geometric morphometrics analysis on overall pelvis shape and its relationship with gut volume reveal a significant correlation between centroid size and gut volume in humans, but not in capuchins. It seems that a pelvis-gut relationship may only be present within hominins or apes. These relationships, however, seem to be driven by males—females do not show statistical significance. Sexual dimorphism should be considered when inferring gut size using skeletal proxies. Future research should include an analysis of a substantial sample of ape abdominal scans.

**Veatch et al.**

## **The taphonomy of extant small animals from Flores, Indonesia: relevance for interpreting anthropogenic behaviors at Liang Bua**

Liang Bua, an archaeological site on the Indonesian island of Flores, is best known as the type locality of *Homo floresiensis*. Excavations at Liang Bua have recovered more than 275,000 vertebrate skeletal elements, 78% and 13% of which represent murines (i.e., rats) and other small animals (body mass < ~5 kg), respectively. Because mammalian carnivores were only introduced to Flores by modern humans ~3 ka and carnivorous reptiles (e.g., Komodo dragons) have extremely high digestive levels that destroy bone, the likely predators responsible for these small animal accumulations at Liang Bua throughout most of its stratigraphic sequence (~190–3 ka) are either avian or hominin. In order for future studies to address how small animals were incorporated into the diets of *Homo floresiensis* (~190–50 ka) and modern humans (hunter-gatherers ~46–3 ka and agriculturalists ~3 ka to present), we collected ethnoarchaeological data on human butchery of extant small game. This generated a known comparative taphonomic sample of small animal bones that were hunted, processed, and consumed by living people from two communities surrounding Liang Bua (Teras and West Bere). Our sample includes birds (n = 2), reptiles (n = 3), amphibians (n = 9), primates (n = 1), bats (n = 7), civets (n = 1), and rats (n = 4). Here, we present 2D and 3D quantitative and qualitative data on mark morphology, frequencies of cut and tooth marks, locations of damage on elements, and bone breakage patterns. Processing damage includes chopping, sawing, and slicing actions that manifest in diverse markings, including both deep and shallow linear scores. In total, these data provide important taphonomic information for how humans process small game and serve as an important comparative collection for further studies of the subsistence behaviors for *Homo floresiensis* and modern humans at Liang Bua.

**Watson et al.**

## **Effects of inter-source variability in the geochemical composition of silcrete on transformations during heat treatment**

Discussions of heat treatment in the Middle Stone Age of southern Africa focus broad generalizations of heating parameters and criteria. However, silcrete is a highly heterogeneous material, and recent research has demonstrated inter-source variability in the response of silcretes to heat treatment. To understand the mechanisms behind this response variability, we undertook a series of controlled experiments in which silcrete from multiple sources in South Africa and Australia were heated to a range of maximum temperatures and examined in both the “dehydrated” and “rehydrated” state using near infrared spectroscopy. Our results demonstrate that variation in porosity and water content between silcrete sources affects the temperature at which thermal transformations begin within different silcretes and the temperature range in which changes occur. These results demonstrate the need for a more individualized knowledge of how different silcretes react to heat treatment and range of variation present within a local region before inferences about the level of complexity involved in the heating process can be made.

**Yeshurun et al.**

## **A Zooarchaeological Test of the “Two-Tradition Model” in the Early Upper Paleolithic Levant: Ahmarian and Aurignacian subsistence at Manot Cave, Israel**

The Early Upper Paleolithic period in the Levant is essential in the studies of the establishment of modern human communities outside Africa, and corresponding archaeological evidence may be used to shed light on human ecology, economy and demography. Specifically, cultural differences between two Early Upper Paleolithic entities, the “local” Early Ahmarian and the Levantine Aurignacian — suggested to represent a short incursion of back-migrating European groups into the Levant — raise the question of differing adaptations. Here we use archaeofaunal remains from the Early Upper Paleolithic sequence of Manot Cave (Western Galilee, Israel), to track human hunting patterns, carcass transport and processing within the Early Ahmarian (46–42 ka) and Levantine Aurignacian (38–34 ka) phases. We test two hypotheses: 1) The Ahmarian and Aurignacian represent adaptations to different environments; and 2) The two entities differ in mobility patterns and site use. Our taphonomic analysis showed subtle

differences in depositional processes between the two phases and demonstrated a primarily anthropogenic complex. In both phases, human subsistence was based on two ungulate species, mountain gazelle (*Gazella gazella*) and Mesopotamian fallow deer (*Dama mesopotamica*), with some contribution from birds, tortoises and small mammals. The prey spectrum and choice, carcass transport and processing patterns in both phases occupy a middle position between the Middle Paleolithic and the late Epipaleolithic of the region. Despite this, there are also several significant differences between the phases such as increased exploitation of small ungulates (gazelle) and small game (especially birds), and greater accumulation of material in the Aurignacian. When evaluated against independent paleoenvironmental proxies, these patterns cannot be ascribed to environmental change but rather indicate greater occupation intensity during the Aurignacian compared to the Ahmarian. This could explain the outstanding archaeological character of the Aurignacian entity in the Levant.

**Zinsious et al.**

## **Site and Assemblage Integrity at Lapa do Picareiro: the Middle to Upper Paleolithic Transition in Portugal From a Secure Context.**

Central Portugal is a critical area of study for addressing the replacement of Neanderthals by Anatomically Modern Humans in Iberia. This poster presents new data on lithic refitting and assemblage integrity from Lapa do Picareiro, a cave in central Portugal containing punctuated levels of occupation within a continuous sequence of sediment deposition spanning the Middle and Upper Paleolithic. These levels contain lithic and faunal remains recovered using high resolution spatial recording methods. The lithic assemblages from Levels JJ, FF, DD, and W, each contain a numbers of refits, allowing us to demonstrate their intact stratigraphic position and to conduct spatial analyses of lithic reduction and activity areas in the Early Upper and Late Middle Paleolithic. Using lithic refits as a measure of site and assemblage integrity, this poster demonstrates the importance of Lapa do Picareiro as a key site for the study of the Middle-Upper Paleolithic transition in southern Iberia.

**Zipkin et al.**

## **Beyond the Swartberg: preliminary findings from an extended strontium isoscape in the South African Karoo**

The use of radiogenic strontium isotope ratios ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) has a long and productive history in archaeological science (Bentley, 2006). Provenance analysis of archaeological hard tissues like enamel, bone, and shell relies upon a reference data set of landscape variation in strontium available for incorporation into the skeleton (bioavailable Sr). The construction of such references, often referred to as a baseline or an isoscape, is a rapidly evolving area of research (e.g. Bataille et al., 2018; Chase et al., 2018; Willmes et al., 2018). In 2016, Copeland and colleagues published a relatively dense, and spatially extensive, sample of bioavailable strontium values in the Greater Cape Floristic Region of South Africa, which were used to create the region's first isoscape. The findings from that study showed Sr isotopic variation tied to geology as well as a zone of marine strontium influence up to 20 km inland from the coast, overwriting much of the signal from local bedrock. The work presented here is a continuation of Copeland's initial efforts. In 2018, we collected 149 plant samples across a ~40,000 square km study area in the Great and Little Karoo of South Africa, partially overlapping with the earlier isoscape sampling range and extending it ~100 km further inland. The three objectives of this project are: 1) to enlarge the isoscape and increase its applicability to additional archaeological sites, 2) to refine the 2016 interpolation using new samples for validation testing, and 3) to examine intra-geological formation Sr isotope variation, particularly for the Adelaide sub-group (Beaufort group) which underlies much of the 2018 study area. The newest results, presented here, cover an 18,000 square km area to the north of the original isoscape and show local geology influenced changes in Sr. The Sr values also exhibit no evidence of marine influence beyond the Swartberg Mountains.