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Comparing lithic raw material procurement strategies during MIS5 to MIS3: the cases of Navalmaíllo Rock Shelter, Buena Pinta Cave and Des-Cubierta Cave (Madrid, Spain)

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Lithic raw materials procurement strategies depend on a series of factors such as e.g., resource availability, accessibility, and orography. This paper presents the results of the lithic raw material study of the Mousterian assemblages from Navalmaíllo Rock Shelter, Buena Pinta Cave and Des-Cubierta Cave sites located in Calvero de la Higuera, a karst hill situated in Pinilla del Valle, in the Lozoya River Valley in the Guadarrama Mountain range (Madrid, Spain). The diversity of occupation contexts in the same geological environment allows for a comparison of resource management and environment occupation strategies between MIS5 and MIS3. Two of the features that highlight the archaeological sites of Calvero de la Higuera from the Iberian pattern of Neanderthal occupation and that motivated their study are their central geographical location and the intensive use of quartz and low chert proportions. A combination of three methodologies involving fieldwork and laboratory analysis were developed to determine the modes of acquisition and management of lithic resources: i) Geological surveys were carried out to take rock samples to map resources, determine and characterize the availability of resources and compare them with archaeological samples. Survey data was recorded using a mobile application designed for the project. ii) Laboratory analyses for macroscopic rock type determination, petrography and SEM / EDX for provenance study by comparing archaeological with geological specimens. iii) Two Experimental Archaeology projects were developed to test the mechanical behaviour of quartz during knapping and abrasion wear. Abrasion experimentation was done in comparison with quartzite and flint samples, the two most used raw materials in Iberian Prehistory. The data gathered allowed for a first approach to the economic analysis of resource exploitation and use in the centre of the Iberian Peninsula by Neanderthal groups. It was concluded that Neanderthals in Calvero de la Higuera sites exploited mainly igneous and metamorphic local rocks. In some levels, there is the presence of exogenous raw materials from as far as 75 km in a straight line. Despite the difficulties in controlling the quartz knapping process, the acquisition and intensive use of quartz represents a practical choice for its abundance in the surroundings, but also the effectiveness of its edges. Results show their ability of technological adaptation to the exploration and use of raw materials with different characteristics. Comparing the relationship between local and exogenous raw materials present at level F of Navalmaíllo Rock Shelter and level 23 of Cueva de la Buena Pinta, it was found that different resource exploitation strategies correspond to distinct climatic periods (MIS5a and MIS 4 respectively) and ways of occupying the landscape. Different strategies may reflect differentiated access to resources and/or changes in mobility strategies motivated by environmental changes.

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An Interdisciplinary Micro-Contextual Laboratory Excavation of Fire Residues from Pech de l'Azé IV (Dordogne, France)

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There is currently renewed debate over the role of fire in Neandertal adaptations. One dataset that features in this debate comes from the Middle Paleolithic site of Pech de l'Azé IV [1, 2]. While there is variability of fire use throughout the sequence, at its base there is a thick, blackened deposit with numerous combustion features (Layer 8). However, while these features are clearly visible in section, they proved quite difficult to excavate during the 2000-2003 field seasons employing field methodologies that have become standard in Paleolithic archaeology [3]. Now, we are re-excavating this layer to better understand variability in Neandertal fire features. For this, we have adopted a microcontextual approach to characterize combustion zones in terms of their surficial features and subsurface attributes, which reflect alterations of sediment and objects within the 3D volume affected by the heat. A plethora of techniques are currently available for archaeological research to target what is often called the invisible record. Our microcontextual approach integrates a variety of these, including geology (microstratigraphy, micromorphology, organic petrology), palaeomagnetics, zooarchaeology, chemistry (gas chromatography-mass spectrometry, infrared spectroscopy), anthracology, lithic analysis, and phytoliths. Traditionally, samples for each of these techniques are collected separately according to technique-specific protocols. Here, we have developed a methodology to integrate and standardize high-resolution, high-saturation sample collection through 100% recovery of sediments using highly controlled laboratory excavations. This way, all researchers are essentially using the same 'contextualized micro samples', so results from each method are directly comparable.

Our procedure is to remove blocks of sediment (70 cm long x 10 cm wide and encompassing the entire thickness of layer 8) while maintaining their integrity and their position relative to the site grid. The blocks are then excavated in the laboratory using a purpose-built cyclone vacuum system to collect all sediments into 50 ml glass vials that are immediately refrigerated. We use several excavation stations simultaneously, each with a Microscribe 3D digitizer to provenience finds and sediments relative to the original Pech de l'Azé IV grid system. This standardization enables multiple subsamples to be taken for different types of analysis from the same vial representing any particular micro-context. In addition, every third sediment block is used exclusively for micromorphology and geomagnetic analysis. These blocks are impregnated with resin and serve as a microstratigraphic "roadmap" for the excavation of the surrounding blocks. To ensure accurate integration of field and lab coordinate systems, we developed programs and workflows for collecting and visualizing the data, including real time projection of excavated points and objects on to a structure from motion 3D models and into augmented reality visualizations of the site.

Our preliminary results show that this microcontextual excavation methodology is operational and it vastly improves the precision and efficiency of our ability to extract and observe microstratigraphic data. In this poster, we illustrate the workflow: from block removal, laboratory excavation, subsampling procedure, and 3D integration of data. The laboratory excavations under controlled lighting reveal subtle changes in the deposits that were not recognizable in the field. It became clear that Layer 8 is composed of several microstrata that vary both laterally and vertically. Ongoing analyses provide data on combustion feature attributes, including the distribution of temperatures achieved, depth of heat penetration, presence/absence of organic residues, and the type of fuel used.

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Ongoing ichnological research at the 300 ka Schöningen archaeological site (Germany)

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The study of fossil footprints (ichnology) is an important line of evidence when reconstructing the topographic, environmental and ecological aspects of prehistoric sites. Such traces were recently discovered at the 13 II "Untere Berme" site, which is part of the well-known 300 ka Lower Palaeolithic site-complex of Schöningen, Lower Saxony, Germany [1]. Here, a 25 m^2 trampled paleosurface is currently under investigation; we are also reassessing similar finds unearthed in 1994 by the State Service for Cultural Heritage of Lower Saxony, found on a 65 m^2 paleosurface at the site Schöningen 13 I [2]. Overall, several dozen animal tracks have been recovered in Schöningen, and are attributed to elephants, rhinos and other middle- and small-sized mammals. The new 25 m^2 trampled surface shows a herd of elephants walking along the shore of an ancient lake. The prints are preserved at the top of a 0.3/0.4 m thick lacustrine sediment layer rich in carbonates (lime mud), grey in colour and with a clayey-silty matrix. This evidence confirms the existence of a walking surface that was partially submerged by water, and lets us understand both the timing and the extent of animal presence at the location and the state of the environment of the ancient landscape. Elephant footprints are very rarely described from Pleistocene sites in Europe [e.g. 3], but they give insight into the lives of such animals, on morphometric features, ecology and their social behaviour [4]. In contrast, the remains of elephants have often been described from Pleistocene sites in Europe. Remains of elephants were also found repeatedly in Schöningen, corresponding to different layers and time events. At least 10 elephants (*Palaeoloxodon antiquus*) have been discovered so far, including two calves and a nearly complete, well-preserved skeleton of a probably female adult of ca. 50 years of age. The latter was surrounded by 30 lithic and 2 bone artefacts [5]. The continuous presence of both hominins and elephants in the Palaeolithic sites in Schöningen, during different times and climatic circumstances, indicates that the landscape around the lake was attractive to both elephants and hominins for thousands of years. Bones, artefacts and footprints offer us the possibility of a better understanding of the landscape and the climate, and in evaluating the resources available for the hominin groups that were able to hunt or scavenge a varied selection of prey in the area.

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Quantifying differences in hominin flaking technologies with 3D shape analysis

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Genetic and climate-driven estimates of past population dynamics are increasingly influential in broader models of hominin migration and adaptation, yet the contribution of stone artifact variability remains more contentious. Scientists are increasingly recognizing the potential of unretouched stone flakes ('flakes') in exploring existing models of hominin behavioral evolution. This is because flakes (1) were produced by all stone tool manufacturing groups in the past, (2) are abundant from the inception of the archaeological record up into the ethnographic present, and (3) preserve under most conditions. The statistical tools of three-dimensional geometric morphometrics (3DGM) capture detailed approximations of flake form that may be challenging to measure with conventional stone artifact analysis methods. Here we analyze a collection of 717 high-resolution 3D scans of experimentally produced flakes from 5 production strategies (Oldowan-like core and flake systems, Levallois, discoidal, bifacial production and laminar) that were commonly practiced by hominins through large parts of the Pleistocene, and that scientists have drawn on also to make demographic arguments about past human behavior (n = 45 reduction sequences, n = 3 knappers that were naïve towards the objectives of this study).

First, as a proof-of-concept, we demonstrate that we can estimate the strategies used to produce these flakes at a high success rate even when flakes from early stages of core reduction are included in the analysis. We frame the significance of this finding against archaeological classifications from several key Middle Paleolithic assemblages in France (n = 4 sites, n = 28 layers, n = 16467 flakes). Second, we show that 3DGM captures subtle differences in these strategies that influence flake formation on a flake-by-flake basis and that reflect decisions made by knappers about platform selection, preparation, and core-surface management. In this poster we explore the broader potential of our model with a cross-validation approach, and we describe a means of assessing flake form on a continuum wherein variability among assemblages separated by large expanses of space and time can be meaningfully analyzed.

The lithic assemblage of the Gran Dolina-TD10.2 kill-butchering site (Sierra de Atapuerca, Spain)

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The Acheulean technocomplex proved to be geographically and chronologically diverse. Currently, its technological variability is explored in terms of economic, social and/or cultural dynamics. Several factors, such as raw material management, local technological traditions and evolution, environmental restrictions or site function are argued to explain this diversity. The archaeological sub-unit of TD10.2 at the Gran Dolina site provides an excellent opportunity to explore these questions. It is part of a Middle Pleistocene long occupation sequence that shows no big changes in environmental conditions or raw material availability, while it hosts very specific activities [1]. Gran Dolina is one of the most important karstic infills of the Sierra de Atapuerca. Unit TD10 is a 3m-thick archaeo-palaeontological layer divided into four litostratigraphic sub-units (TD10.1-TD10.4) at the top of the sequence. These are currently fully excavated and are dated between MIS11 and MIS8. Sub-unit TD10.2, the focus of this study, is composed of around 12.000 lithic and 60.000 faunal remains. Based on the zooarchaeological and taphonomic investigation, this layer has been interpreted as a monospecific bison kill-butchering site. Moreover, this has been considered as the first evidence of communal hunting documented in human evolution, reflecting high capacities and social complexity of the pre-Neanderthal group that occupied the cave [2]. This study aims to present for the first time the lithic assemblage of TD10.2 by providing results on raw material management, techno-typological characteristics, refitting sequence and functional analysis. This will enable us to recognise and define key-features of a kill-butchery toolkit and provide important information on the production of specific tools and their use. This new data will add significant highlights in the subject of Acheulean diversity. Preliminary technological results revealed a marked specialization in the raw material management, clearly distinguished from the other deposits of Gran Dolina [3]. Almost all of the lithic artefacts (around 96%) are made on local chert. Presence of fluvial raw materials (quartzite, quartz and sandstone) is really scarce. The ongoing studies show that the assemblage is dominated by flake products with presence of high diversity of small flake tools. Most of these tools are side-scrapers and denticulates, but some points and multipurpose tools are also present. In contrast, large cutting tools, represented mainly by bifaces, are sparse. Cores are dominated by centripetal reduction systems with little glimpse of the so called "prepared core technology". Preliminary results indicate a high integrity of the site with the presence of complete <*chaînes opératoires*> and several refit sequences. The conservation of the lithic artefacts (particularly those of Neogene and Cretaceous chert) is poor; however, given the importance of this sub-unit and the lithic assemblage itself, an attempt was made to undertake also use-wear studies. For this, the best preserved and apparently fresh pieces were selected. These were studied by means of different microscopes (optical, digital 3D and scanning electron). Preliminary results show poor but actual preservation of use-wear traces, among which butchery-related features stand out.

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Do dentine and cortical bone thickness covary in humans? The influence of age and sex assessed in a modern sample and the condition of Neandertals

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Differences in tooth dentine and cortical bone thickness and distribution have been independently reported between modern humans and Neandertals, with the latter typically displaying greater volumes of radicular dentine and thickened long bones [1-3]. The functional hypothesis, i.e., the adaptation to more severe loads, is often put forward to explain these differences. However, few research has combined the study of dentine and cortical bone to ultimately explore the possibility of a related role played by genetic, epigenetic, and environmental factors on the morphogenesis and development of these mineralised tissues. Indeed, dentine and cortical bone share similarities in their embryological origin and development, which is regulated by several common genes, hormones and signalling pathways. The aims of this study were to quantify dentine and cortical bone thickness in a sample of immature and adult modern humans in order to identify their possible covariation and to evaluate to what extent aging and sex influence their developmental patterns. Finally, we compared our results with the signal from some immature and adult composite Neandertal representatives. The canine and distal extremity of the radius were selected as they have been proposed to be under less biomechanical constraints than other teeth and long bone elements. Absolute volumetric variables and 3D relative indices expressing tissue proportions were measured on a microCT record of maxillary canines (UCs) and distal radii in a sample of 11 immature individuals of unknown sex (aged from circa 9 to 19 years) and of 18 adults (8 males and 10 females) selected *ad hoc* from French medieval cemeteries. The composite immature Neandertal is represented by the association of the D24 deciduous UC canine from Krapina (MIS 5e, Croatia) and the radius from the Roc-de-Marsal 1 specimen (MIS 4, France); the adult Neandertal individual results from the association of six UCs from Krapina (D36, D37, D56, D76, D139, D146) and the UC Vindija 12.5 from Vindija (MIS 4-3, Croatia) with the radii from the partial skeletons Regourdou 1 (MIS 5c-4, France) and Spy 6 (MIS 3, Belgium). We quantified the 3D Relative Dentine Thickness (3D RDT), a measure similar to the classic 3D Relative Enamel Thickness [4] adapted here to the dentine and pulp components and the 3D Relative Cortical Thickness (3D RCT [5]; similarly adapted to the cortical bone and medullary cavity components). 3D RDT was computed between 60% (apical) and 90% (subocclusal) of the total root length for volumes portions representing 10% of the root length and for the crown dentine. 3D RCT was calculated for 10% portions between 20 (distal) and 50% of the biomechanical length of the radius. In both the extant human sample and the composite Neandertals, the whole results indicate covariation between dentine and cortical bone among the immatures, while this signal is not detected in the adults. Among the extant adults, males show the highest correlation between the mid-root dentine and the most distal part (20-30%) of radius, whereas in female this occurs between the crown dentine and again the most distal part of radius. The Krapina/Roc-de-Marsal composite immature Neandertal has relative and absolute proportions of coronal dentine and cortical bone that fall outside the extant human range, whereas the mature Neandertal chimeras do not differ in these proportions from our reference sample. At least in part, this could reflect ontogenetic differences between the two taxa. Despite the limited number of specimens considered in this study, the differences recorded in both extant humans and Neandertals in the pattern of dentine-cortical bone covariation between immatures and adults confirm the need for clarifying the role distinctly played by genetic/metabolic and environmental/culturally-related factors on the evolution of mineralised tissues in extinct hominins.

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Can dental topography infer the diet of two of the most controversial extinct cercopithecine species in the South African Plio-Pleistocene?

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A wide variety of primate taxa is represented in the Plio-Pleistocene deposits of South African caves. Until now, almost all the recovered fossil primates belong to the *Papionini* tribe (family *Cercopithecidae*, *Cercopithecinae* subfamily), representing 12 species and 5 genera. Of all the documented cercopithecine extinct species in South Africa, two of the most controversial genera and species are *Dinopithecus ingens* (found in Swartkrans and Skurweberg) and *Gorgopithecus major* (found in Coopers Cave A/B and Swartkrans), as their phyletic relationships and ecology remain unclear [1]. The *Papionini* tribe is especially interesting because it probably shows marked homologies that have complicated the phylogenetic interpretation since morphological studies have no consensus with molecular data. Phylogenetic analyses based on morphological traits have suggested grouping the smaller and less prognate taxa *Cercocebus* and *Lophocebus*, as well as the robust *Mandrillus* and *Papio* taxa, with *Theropithecus*. However, mitochondrial DNA analyses support the relationship between *Cercocebus* and *Mandrillus* (C/M clade) and between *Lophocebus*, *Papio*, and *Theropithecus* (L/P/T clade) [1]. Moreover, a recent phylogenetic analysis suggests that both *Dinopithecus* and *Gorgopithecus* are taxa of the L/P/T clade [1]. Since most of the fossil remains recovered are teeth, they have become the object of numerous works to infer phyletic relationships and paleoecological adaptations. Diet, a major evolutionary factor affecting primate life histories, provides significant clues to the understanding of adaptation and ecological niche separation in primates. The use of dental topography (DNE, OPCR, RFI, PCV) to mathematically quantify the shape of the occlusal surface of the molars has become a valid method to infer the all-year-round diet of extant and extinct species and during periods of scarcity [2]. Fallback foods have been considered biomechanically demanding challenges for food processing, and probably are key items determining dental morphology in relation to both dental morphology adaptations and dental wear [3]. The studied sample consisted of high-resolution 3D dental scans of upper M3 (N = 287) from two fossil taxa (N = 14 for *Dinopithecus*, N = 11 for *Gorgopithecus*) and 10 extant African *Papionini* species (N = 262), used as a comparison sample. Unworn and lightly worn teeth have been used. Preliminary results showed high DNE and RFI values of the upper molars of *Dinopithecus ingens*, similar to those observed in *Papio* and *Theropithecus gelada* specimens, which consume fibrous items in African savannahs and high-altitude grasslands with seasonal changes, such as USOs consumption during periods of scarcity. On the other hand, *Gorgopithecus major* showed greater variability and high values of DNE and RFI -like fibrous-food eaters-, as well as PCV. High levels of PCV are highly correlated with hard-object feeding, such as mangabeys, which consume large amounts of hard cover seeds. *Dinopithecus* topographic results are consistent with previous reconstructions. Both microwear and isotope analyses suggested that it could be a highly opportunistic feeder, like most of the taxa of the *Papio* genus, with fruit as the main element of the diet. However, the diet previously described for *G. major* is controversial. The microwear indicated a mainly folivorous diet (like *Colobus guereza*), while the shear ratio values suggested a highly fruitful diet. Since both species are part of the L/P/T clade, these results could indicate that G. major had a more generalist dental morphology than *Dinopithecus* and the rest of its clade species in response to the consumption of various types of food items, including both fibrous and hard exocarp fruits as fallback food resources

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Reduction intensity in Oldowan Assemblages: Perspectives from BD 1 at Ledi-Geraru, Ethiopia

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There is a growing body of research that utilizes the use-life of stone artifacts as a means of understanding human behavior, management of resource utilization, and landscape use [1]. Previous research on the use-life of retouched stone artifacts has shown the significant contribution of the subject to understanding behavioral change in the past [2]. Despite the informative nature of such studies, measures of reduction intensity are seldom applied to Oldowan sites. However, this represents one of the largest bodies of information about ancient stone tool making groups. Here we examine core reduction patterns at the currently oldest known Oldowan site of Bokul Dora 1 (BD1) from the Ledi-Geraru region of Ethiopia [3]. We employ two methods by Douglass et. al. [4] and Lombao et. al. (2019). These methods utilize linear models of core reduction developed using experiments that were created to simulate Oldowan core reduction techniques. We apply the results of these linear models to archaeological collections to understand different methodologies to gain insight into the utilization of cores with this assemblage. In doing so, we also are able to examine how various core reduction models influence the outcome of such analyses. Our results show that each method for quantifying reduction intensity here results in wide ranging differences in the predicted amount of core reduction intensity. Our application of the Lombao et al [5] method predicts more core reduction intensity. There appear to be direct relationships with reduction intensity and the number of exploitation surfaces in several methods. Even with the high correlations with reduction intensity there are some cores with high numbers of exploitation surfaces that have resultant mass loss predictions that are relatively low. Cortex percentage shows an inverse correlation with predictions of core mass lost. This is particularly apparent with the Douglass et al [4] method, where the relationship is linear. The prediction result using the Volumetric Reconstruction Method, on the other hand, shows a complex relationship with cortex percentage. Some values of cortex proportion directly relate with prediction estimation, at the same time other values of the same variable happen to have an inverse relationship in this method. We further explore more complex methods of reduction intensity prediction using machine learning methods. We investigate the underlying assumptions associated with these methods, especially methods that integrate measurements of flakes as well as cores. Finally, the behavioral implications of core reduction intensity patterns at BD-1 are discussed.

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Unravelling the chronology and character of Neanderthal and Modern Human use of Shanidar Cave, Iraqi Kurdistan

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Shanidar Cave in Iraqi Kurdistan is an iconic site in Palaeolithic archaeology as a result of the 1951-1960 excavations by Ralph Solecki [1]. His discovery of the skeletal remains of 10 Neanderthals, some of which he thought had been killed by rockfall and others buried with funerary rites, including one with flowers, has played a central role in shaping debates about Neanderthal behaviour. Above the Neanderthal (Middle Palaeolithic/Mousterian) layers, grouped by Solecki as 'Layer D', were layers with Upper Palaeolithic 'Baradostian' lithic material grouped as 'Layer C'. The appearance of the Baradostian was assumed to denote the presence of <Homo sapiens> ('modern humans'), though no hominin fossil remains were found to confirm this association. Solecki suggested that there was a clear separation between the terminal Mousterian and earliest Baradostian by a temporal hiatus of some 10,000 years. However, the complex nature of the cave stratigraphy and limitations of the dating techniques he had at his disposal mean that many questions regarding the nature and timing of the transition from the Mousterian to the Upper Palaeolithic at Shanidar Cave, how the cave was used in similar or different ways by Neanderthals and modern humans, and the nature of any interactions between these taxa, remain unclear. Given the documented presence of both late Middle Palaeolithic technology and associated hominin (Neanderthal) remains, as well as early Upper Palaeolithic cultural material, evidence from Shanidar Cave may offer important insights into the nature of the Middle-Upper Palaeolithic transition in this region and potential interaction between Neanderthals and modern humans. A programme of new excavations began in 2015, concentrating on the central part of Solecki's 14 m-deep trench where most of the Neanderthals were found.These excavations have found further Neanderthal skeletal remains, namely part of the individual Solecki classified as Shanidar 5 [2] and an articulated partial skeleton immediately adjacent to the 'flower burial' currently classified as Shanidar Z [3], as well as new data permitting a re-evaluation of late Pleistocene hominin activity at the cave. In this presentation we discuss the new work's emerging results regarding: (1) the chronostratigraphy of the 'Layer D' and 'Layer C' sediments, which indicates a more complex transition than the clear separation by a hiatus that Solecki advocated; (2) the similar character of much of the occupation evidence (single occupation hearths) associated with both Mousterian and Baradostian material culture; (3) the climate proxy evidence associated with these occupations suggesting primary use of the cave in MIS 5-3 during periods when climatic conditions were more or less similar to those of today; (4) with no fossil evidence yet found for modern humans at the site (eDNA samples down the profile are in course of study), the challenges of defining the Middle/Upper Palaeolithic transition, with its connotations of the replacement of Neanderthals by modern humans, using stratified artifactual evidence that includes new finds of shell beads across the transition zone.

We wish to thank the Kurdistan Regional Government for the original invitation to G.B. to plan new excavations at Shanidar Cave, and the Kurdistan General Directorate of Antiquities for permission to conduct these excavations and to study the finds, as well as for invaluable logistical support. We gratefully acknowledge financial support from the Leverhulme Trust (Research Grant RPG-2013-105), the Rust Family Foundation, the British Academy, the Wenner-Gren Foundation, the Society of Antiquaries, the McDonald Institute of Archaeological Research at the University of Cambridge and the Natural Environment Research Council Oxford Radiocarbon Dating Facility (grant NF/2016/2/14).

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Resolving the timescale of South-Central African palaeoenvironments and their impact on human behaviour and evolution

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Dating is integral to the study of archaeology and palaeoenvironments, but is especially problematic beyond the limit of radiocarbon dating, ca. 60 ka. Several dating techniques are widely applied, each with their own set of assumptions and limitations, with no one technique able to span the entire Quaternary (2.58 Ma) for all sample types. Analysis of intra-crystalline protein degradation (IcPD) exploits the time-dependent breakdown of proteins (such as racemisation of amino acids) in a wide range of biominerals (mollusc shell, eggshell, coral, tooth enamel). IcPD targets the intra-crystalline fraction of protein within the biomineral, which having effectively formed a closed system, minimises the effects of contamination, leaching and many other impacts of the depositional environment. IcPD has been successfully employed as a relative dating technique at a range of archaeological and palaeoenvironmental sites across the world, providing robust and reliable relative geochronologies on Pleistocene timescales.

The South-Central African region is increasingly thought to have played an important role within mammalian (and especially hominin) evolution during the Quaternary, having yielded hominin fossils (e.g. the (*Homo heidelbergensis* (*rhodesiensis*)) Kabwe cranium), evidence of changing tool technology and early pigment use (~265 ka). Ecologically, the region was once an extensive palaeo-wetland, encompassing the Okavango delta, the Makgadikgadi pan and the Zambezi and Kafue rivers, not only providing a migratory corridor between Southern and Eastern Africa, but an ideal climate for mammalian and hominin habitation in its own right. By targeting a number of biominerals (notably *Achatina* mollusc shell and tooth enamel from a number of mammalian species) from sites across the region, we aim to provide a series of accurately dated geochronologies with potential for wider application across Africa, helping to elucidate critical archaeological and palaeoenvironmental questions. This poster presents the first IcPD studies using biominerals from the Twin Rivers site in Zambia, notable for its MSA tools and early pigment use.

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Vertebral trabecular bone structure in *Homo, Pan* and *Papio*: implications for the identification and biomechanical interpretation of early hominin vertebrae

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The vertebral column constitutes a key region for reconstructing past hominin biomechanical environments given its role in posture, locomotion and bearing carried loads. Trabecular bone structure and mechanical properties of vertebral bodies reflect genetic variation as well as the nature, direction, frequency, and magnitude of biomechanical loads during locomotion and object manipulation [1-2]. However, the scarcity and fragmentary nature of the fossil record severely limits our ability to infer the postural, locomotor and behavioural repertoire of early hominins from vertebral remains [3]. Besides the difficulty of identifying the position of isolated vertebral elements within the column of a given species, depositional association of early hominin remains with large papionins can confound the classification of fossil hominin vertebrae [3-4]. Given the potential implications for the taxonomic assignment of isolated and/or partial specimens and the assessment of postural, locomotor and perhaps other behaviours (e.g., load carrying) in fossil hominin taxa, here we test the possibility that salient taxon-specific features and functional differences could be identified in the trabecular bone structure of the cervical, thoracic and lumbar vertebral bodies of *Homo*, *Pan* and *Papio*. Our sample consists of complete vertebral columns of extant *Homo* (N = 4), *Pan* (N = 4, including *P. paniscus* and *P. troglodytes*) and *Papio* (N = 4, including *Pa. anubis* and *Pa. hamadryas*) from the collections of the University of Pretoria (South Africa) and the Royal Museum for Central Africa (Belgium) investigated by X-ray microtomography at the South African Nuclear Energy Corporation (South Africa) and Ghent University (Belgium). Structural properties (i.e., bone volume fraction, degree of anisotropy, trabecular thickness and spacing) were quantified in a volume of interest placed at the centre of the vertebral body, excluding the cortical shell. When considering the whole column, the trabecular network is well organized and particularly dense in *Pan* and *Papio*, while trabeculae in *Homo* are comparatively thick and widely spaced. Moreover, the trabecular bone structural variation pattern within the vertebral column differs between the three taxa. Our promising preliminary results thus support the potential of the vertebral trabecular bone for discriminating among species and postural and locomotor behaviours. Besides providing a comparative database for identifying hominin vertebrae in the fossil record, this study will be used in the future to detect functional signals preserved in the vertebral trabecular bone of early hominins and contribute to the ongoing discussion on the significance of arboreality in their locomotor repertoires [5].

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Prevalence of Cranial Trauma in Upper Paleolithic Humans

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Technological, cultural and behavioural innovations are unique characteristics of the Upper Paleolithic. Marked climatic and environmental changes over the course of several millennia exposed Upper Paleolithic human populations frequently to elevated stress levels and prompted biocultural adaptations of survival strategies regarding subsistence, technology and social life which acted as buffer against environmental conditions. Traumatic injuries are directly linked to the lifestyle and organization of a population and can serve as indicators of the stresses sustained by a population. Despite their potential to gain insights into hazardous environments, violent behaviours or the age- and sex-differentiated involvement in risky activities, trauma patterns of Upper Paleolithic humans have rarely been addressed under a population-perspective. Employing a population-level approach, this study aims to quantify the prevalence and characterize the patterns of cranial trauma in a large sample of Upper Paleolithic fossil specimens (40,000 – 10,000 BP). We compiled an exhaustive database from the literature comprising 234 individual crania (specimens), representing 1285 cranial bones (skeletal elements) with and without traumata, from 101 Eurasian Upper Paleolithic sites. We used generalized linear mixed models with a Markov chain Monte Carlo algorithm to assess trauma prevalence in relation to age-at-death, sex, anatomical distribution, and between humans before and after the Last Glacial Maximum (LGM), while accounting for the differential preservation of the remains. Results suggest a predicted mean cranial trauma prevalence of 0.07 (95% CI 0.003-0.19) at the level of skeletal elements, and of 0.26 (95% CI 0.08-0.48) at the level of specimens, each when 75-100% complete. The cranial trauma prevalence of Upper Paleolithic humans hence is similar to the variation found in Mesolithic and Neolithic samples. Across specimen and skeletal element datasets, trauma prevalence was higher in males and in the old age group, suggesting that Upper Paleolithic males and females were exposed to slightly different injury risks, potentially due to sex-specific activities or behaviours; both sexes exhibit more trauma among the old. Moreover, trauma prevalence was higher in neuro- than in viscerocranial remains, with neurocrania being affected predominantly in males. We found no time period-specific trauma prevalence patterns for the two sexes or age cohorts when comparing samples from before and after the LGM. Environmental stressors associated with climatic instabilities during the LGM seem not to be reflected in cranial trauma prevalence.

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An improved chronology of the Middle Stone Age in El Mnasra cave, Northwestern Africa

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Over the last 20 years, there was a renewed interest for coastal North African Middle Stone Age sites. One of them is El Mnasra cave (Rabat-Temara region), a rare example in North Africa of coastal caves with well-preserved Middle Stone Age occupations in stratified sequences with evidence of behavioural complexity including pigments, bone industry and marine shells used for ornamental purposes [1]. This site is associated with evidence of marine resources exploitation notably through the presence of marine shells and presents a great interest to study livelihood strategies adopted by early *H. sapiens* in coastal areas in relation to the production of symbolic and cognitive hallmarks.

At El Mnasra cave, a total of 25 dates were obtained prior to this study (see synthesis in [2]) and placed the MSA occupations within the MIS 5e and MIS 4. However, the existing combined US-ESR dates are younger than the OSL dating of the same levels. This discrepancy has been observed repeatedly but no definitive arguments have been put forward to explain it. Several biological disturbances have been observed locally, related to Honeybadgers (*Mellivora capensis*) or to Neolithic burials which might have induced mixing of sediments and materials in some locations [3]. In the light of a fresh assessment of the site's stratigraphy based on lithostratigraphic units, a new dating campaign was engaged to date the most intensive MSA human occupations which yielded evidence of marine shells exploitation and to date the end of the MSA.

We provide firstly new paleodosimetric dates (OSL and combined US-ESR) associated with dosimetric fieldwork campaign. Then, we propose a chronostratigraphical model based on a Bayesian approach for the Middle Stone Age cultural sequence for El Mnasra. Despite difficulties with individual ages samples (e.g the precision of the dates, non-representative average γ-dose-rate,...), the Bayesian approach makes it possible to combine the 32 radiometric dates available for the cave (OSL and combined US-ESR) with 95% probability. We characterized each MSA level with the time range interval. The main results from this work are: (a) the considerable extension of the age of the final MSA occupations until the boundary between MIS 4 and MIS 3; (b) the earliest record of perforated *Nassarius* sp. shells know so far Africa, between ∼105-86 ka.

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Internal bone architecture in the capitate of extant hominids

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Due to its central role in wrist function and distinctive morphology, the capitate has been an important element for drawing inferences about fossil hominin locomotor and manipulative capacities [1-3]. However, difficulties in studying the numerous, intricate joints of the wrist have led to disagreement about the functional significance of various aspects of its morphology [1-3]. As internal bone is known to adapt to load experienced during life, its structure may reflect the actual postures and behaviours of an individual [4,5]. To date, it is unclear whether the internal bone of the capitate might reflect differences in hand use among hominids. Furthermore, it is not currently understood how cortical and trabecular bone of carpals interact and adapt to cope with the high load and mechanical demands of suspensory or quadrupedal locomotion. To examine the relationship between internal bone architecture and locomotor behaviour, we test for group differences in bone volume to total volume (BV/TV), degree of anisotropy (DA), and cortical thickness (Ct.Th). Further, we analyse the relative distributions of cortical and trabecular bone to assess whether distribution is similar between the locomotor groups. Using a whole-bone method (http://www.dr-pahr.at/medtool/), BV/TV, DA, and Ct.Th were measured in four extant ape genera (n=69) representing bipedal (*Homo*), knuckle-walking (*Pan, Gorilla*) and suspensory (*Pongo*) locomotion. The capitate was partitioned for separate analysis as the proximal portion forms part of the midcarpal joint, while the distal portion forms part of the carpometacarpal joint [3]. BV/TV was measured twice, quantifying just the trabecular region and then the combined cortical and trabecular region. Mean group differences were examined with a Kruskal-Wallis one-way ANOVA and Pairwise Wilcoxon Rank Sum test. Intraspecific ratios were calculated to facilitate comparison of the bone parameters between the proximal and distal regions of each genus. Parameters differed between the genera across all capitate regions ($p=<0.001$ for all tests), except distal DA ($p= 0.593$). Ct.Th was the most important parameter for differentiating locomotor groups as distribution across the bone was distinctly different between the human and non-human apes. Compared to the proximal, the distal cortex was thicker in all genera; a 12% increase was seen in *Homo*, 52% in *Pan*, 62% in *Gorilla* and 79% in *Pongo*. This Ct.Th increase coincides with the attachment sites for several ligaments, and might indicate that tensional strain, which has a lower failure load than compressive strain, has an impact on cortical bone functional adaptation. These intergeneric differences further suggest that the hand of bipedal *Homo* may not experience a similar magnitude of strain. Trabecular BV/TV was higher in the proximal capitate for all genera suggesting it plays a bigger role in adapting to midcarpal joint load than cortical bone in this region. DA in the distal capitate was not significantly different among the genera. This may indicate that the limited mobility at the distal region results in a similar DA, irrespective of hand use. *Homo* and *Pongo* were differentiated from the knuckle-walking taxa by having higher DA in the proximal capitate, which was unexpected given our assumption of more variable wrist postures than that of knuckle-walking apes. Results of this study indicate that (1) capitate bone structure is informative for reconstructing hand use and (2) partitioning of 'cortical' and 'trabecular' regions in carpals (and likely tarsals) may obscure functionally relevant information in the carpus of hominids.

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Out of Savannahstan: Multiproxy evidence on fauna (stable isotopes, ecometrics, tooth mesowear, small vertebrates) from the oldest hominin sites in Southwestern Europe (Orce, Guadix-Baza Basin, Spain)

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A key question in human evolution concerns the circumstances that led to the first dispersal of *Homo* across Eurasia. The so-called Savannahstan or savanna hypothesis argues that early *Homo* adaptation was relatively inflexible and that these hominins were closely tied to savanna and grassland environments. Consequently, hominins would have taken advantage of a spread of savanna and grassland biomes in Eurasia, dispersing within the same ecological context as was their original home in Africa. Variability selection hypothesis, however, argues that, very early on, hominins became ecologically flexible and were able to expand in different ecosystems. Here we test the savanna hypothesis by using multi-proxy approach to reconstruct the palaeoenvironmental context of the earliest hominin sites in Western Europe in Southern Spain.

The Guadix-Baza Basin (Granada Province) provides one of the richest records in Western Europe to study the early hominin dispersal and evolution. It has yielded the oldest localities with evidence of hominin occupation (a deciduous human molar, lithic industries and cutmarks on bones) together with a rich large and small vertebrate assemblage dated to around 1.4 Ma. Possible environmental differences between one older site lacking unambiguous evidence for hominin occurrence (Venta Micena,∼1.6 Ma) and younger sites with undisputable evidence (Barranco León and Fuente Nueva-3, ∼1.2-1.5 Ma) were investigated using various approaches, including carbon and oxygen isotopes in tooth enamel, tooth wear analysis, ecometrics and microvertebrates (amphibians, reptiles, mammals) as proxies for palaeoenvironment.

Tooth enamel powders were collected from a large diversity of herbivorous taxa, including cervids, bovids, equids, rhinoceros, hippopotamus and mammoths. For several specimens, enamel was sampled serially to document intra-annual dietary and/or habitat changes for the studied individuals. The analyses were conducted at the University of Tübingen (Senckenberg Centre for Human Evolution and Palaeoenvironment). Carbon isotopic results from the three sites showed that the plants foraged by herbivores were trees, shrubs and C3-grass adapted to mild growth season, which is consistent with the results of tooth wear analysis indicating browsing or mixed feeding with browsing preference for most taxa. The regular consumption of some C4 plants for some herbivores has been detected only in Barranco León. This is consistent with the results of palaeoclimatic investigations based on ecometrics and microvertebrate fauna, indicating a particularly wet and warm climate as compared to Fuente Nueva-3 and, especially, to Venta Micena, the site devoid of hominins. The differences in isotopic results among taxa are in agreement with those of dietary preferences from mesowear tooth analysis. In addition, in a context of Mediterranean climate with 4-months aridity during summer, isotopic variations within teeth suggest in some cases significant changes in foraging throughout a year, which could be related to local seasonal changes or mobility across areas with different vegetation types.

The first results of this multidisciplinary research project financed by the Leakey Foundation and a General Research Project from the Andalusian Regional Government help us to refine the palaeoenvironmental reconstructions around the time of the earliest arrival of hominins in Southern Spain. In combination with the climatic data provided by ecometrics and microvertebrate investigations, the carbon and oxygen isotopic data from tooth enamel indicate a Mediterranean climate and biome with seasonal differences in precipitation and with forest, woodland and shrub vegetation rather than a grassland or savannah ecosystem. This does not support the savanna hypothesis, but suggests that already the earliest hominins lived out of savannahstan in Early Pleistocene Europe and were able to thrive in variable environments.

The rich dynamics of hominin evolution in low population-density corridors between more densely populated areas

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Palaeogenetics have shown that admixture between different groups may be the rule rather than the exception in hominin evolution. Especially the discoveries at Denisova Cave show a rich history of interaction between Neanderthals, Denisovans and potentially other, unknown, groups. The present-day climate of the Denisova area in South Siberia is relatively harsh and has probably been such in the past as well (if not worse at times). One may expect that population densities have been low in Southern Siberia and on the adjacent high-elevation mountain ranges and Tibetan plateau. This vast area separates the fertile planes of China and Mongolia from those of SW Russia, that probably had much higher carrying capacity most of the time over the last few hundred thousands of years.

We used an adaption of the stochastic evolution model of Bons et al. [1] to investigate the effect of having a low-population density area between two with a high population density. The demic diffusion rate decreases with population density. This results in more variation and as a consequence development of nation-like regions and an increased propensity to initiate migration waves. The relatively high demic diffusion rate in low population-density areas results in fast spreading and admixture of genes and traits, and therefore reduced clines that suppress the formation of nation-like regions and initiation of migration sweeps. There is, furthermore, an asymmetry in the interaction between adjacent low and high population-density areas. The latter ones are more likely to pass their genes and traits on to the other, or to replace them in a migration wave.

A low population-density area or corridor between two densely populated ones is thus expected to show the effects of genes and traits diffusing in from both adjacent areas, as well as the occasional migration wave. Such waves and demic diffusion fronts are, however, less likely to affect the high population-density areas. A low population-density area would thus show rich population dynamics that, however, are of relatively minor importance to the main population centres, such as East Asia, Southern Russia and Europe, and Africa.

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Orientation and proportions of the carotid canal in *Epipliopithecus* and *Pliobates*

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Although a wide diversity of Miocene small-bodied catarrhines has been recorded [1], our understanding of their evolutionary history, and thus of their implication for human origins, is still hindered. Even the phylogenetic relationships of species known from partial skeletons remain controversial, as illustrated by *Pliobates cataloniae* [2], described from Abocador de Can Mata locality ACM/C8-A4 (Vallès-Penedès Basin, NE Iberian Peninsula) and dated to ∼11.6 Ma [3]. Originally interpreted as a late-surviving stem hominoid based on a formal cladistic analysis [2], it has been subsequently recovered as a pliopithecoid (i.e., stem catarrhine) by another cladistic analysis [4].Deciphering the phylogenetic position of *Pliobates* is important for understanding the origin of modern apes: if this genus is indeed a stem hominoid more derived than proconsulids, the crown hominoid last common ancestor might have been more gibbon-like than generally assumed [2], which would have important implications for unraveling the subsequent evolution of apes and humans. One of the most intriguing features of *Pliobates*, according to the original description, is the hylobatid-like orientation of the carotid canal [2]. Given the potential phylogenetic importance of this anatomical structure [5], here we rely on 3D imaging and morphometric techniques based on μCT data to quantitatively compare the orientation and proportions of the carotid canal in *Pliobates* with a sample of extant catarrhines and the middle Miocene pliopithecid *Epipliopithecus vindobonensis*. Our extant comparative sample includes 76 specimens from 26 catarrhine species representing all cercopithecoid subtribes and all non-human hominoid genera. Each carotid canal was first segmented and the extremities of the resulting 3D surface were cut through homologous planes using a semiautomatic iterative protocol based on petrosal landmarks. Canal orientation was assessed by measuring the 3D angle between the vector connecting the centroid (centerpoint) of the two ends of the canal and a standard reference plane computed after performing a Procrustes alignment based on petrosal landmarks. Using four equally spaced points along the canal streamline between the two canal ends, we calculated the canal length (L). Canal volume (V) was also measured. A dimensionless index of canal proportions was computed as L/V1/3. A bivariate allometric regression of ln L vs. ln V does not enable to reject the null hypothesis of geometric isometry (slope not significantly different from 1/3), indicating that the index is unaffected by size-scaling effects. Carotid canal angles and indices were compared among extant catarrhine families using non-parametric Kruskal-Wallis tests and Bonferroni corrected Mann-Whitney post hoc pairwise tests. Fossils were compared with extant families using z-scores. Our results show that, although hylobatids tend to have less inclined carotid canals than other extant catarrhines, there are no significant differences among extant catarrhines. In contrast, despite considerable overlap, hominids have significantly slenderer canals than both cercopithecoids and hylobatids. While *Epipliopithecus* fits well with all extant catarrhine families in terms of carotid canal proportions, it significantly differs from hominoids by displaying a more inclined carotid canal, overlapping with the upper-most range of cercopithecids. In turn, *Pliobates* differs from *Epipliopithecus* in displaying a less robust and less inclined carotid canal, and does not significantly differ from the variation of extant catarrhine families. Our results for *Epipliopithecus* are consistent with the stem catarrhine status customarily supported for this taxon, but the sample should be enlarged further to test whether its highly inclined canal reflects the plesiomorphic condition for crown catarrhines. Although not conclusive due to the extensive overlap between hominoids and cercopithecoids, our results indicate that the carotid canal of *Pliobates* is much less inclined than that of *Epipliopithecus*, and may thus be consistent with the more derived phylogenetic postion previously proposed for this taxon [2]. Further analyses including more extant and extinct anthropoids would be required to test the phylogenetic signal embedded in carotid canal morphology and its phylogenetic implications.

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Variation pattern of the imprints of the middle meningeal vessels in extant human endocasts

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Our knowledge of the endocranial vascular system in fossil hominin taxa partly relies on imprints of the middle meningeal artery and emissary veins on the inner surface of the braincase. Comparative analyses of the middle meningeal vessel pattern in *Australopithecus* and *Paranthropus* revealed substantial inter- and intra-specific variation [1]. For now, there is no consensus on the physiological implications of the organization of the middle meningeal vessels, even if the thermoregulation hypothesis has been favoured. Interpreting structural changes in the endocranial vascular system in the light of the sulcal variation pattern will be of interest for developing physiological hypotheses and investigating the potential coevolution of the brain organization and the vascular network [2-3]. In this context, the present study aims to characterize the variation pattern of the middle meningeal vessels in extant human endocasts (i.e., replicas of the inner surface of the braincase). This atlas will be used as a comparative platform for interpreting the diachronic and inter-taxic variation of the fossil hominin vascular system. We investigated a total of 10 extant human individuals (equal proportion of adult males and females) from the Pretoria Bone Collection (South Africa). All of the specimens were detailed by X-ray microtomography at a spatial resolution ranging from 99 to 114 µm at the South African Nuclear Corporation in Pelindaba (South Africa). Vascular imprints were detected using a geometry-based method and manually corrected through a customized script written in MATLAB R2013a [1-2]. The detected imprints were identified by referring to available atlases and publications documenting variation in the extant human brain. Additionally, we applied the scoring system introduced by Adachi [4] for characterizing the branching pattern of the middle meningeal vessels. According to this classification, the middle branch can either derivate from the anterior branch (type I), from the posterior branch (type II), or from both (type III) [3-4]. Our results indicate that in our sample of 20 hemispheres, type I is more frequent (50%) than type II (35%) and type III (15%), which is consistent with previous studies of the middle meningeal vessels in extant humans [4]. Additionally, in most of the specimens (80%), the branching pattern identified in the right and left hemispheres are similar, thus supporting a certain degree of symmetry in the endocranial vascular pattern. Interestingly, within the limits of our sample, specimens showing asymmetry and/or a type III branching pattern are all males. However, differences between males and females are not statistically significant. Besides challenging the use of the branching pattern of the middle meningeal vessels as a potential diagnostic feature [5], the relatively high degree of intra-specific variability revealed in our study raises critical questions on the significance of such variation in the human brain evolutionary history [4]. Future quantitative analyses of the imprints of the middle meningeal vessels in extant human endocasts, such as fractal dimensions [4], will be fundamental for characterizing further the degree of reticulation and organization of the branches.

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Searching for new pieces of the Cradle of Humankind in Southern Africa: HON and HOMME research programs

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For decades, the great East African rift has been considered a cradle of humankind. Eastern African archaeological and paleontological sites have yielded fossils of the oldest *Australopithecus* evidence in Africa, stone tool assemblages and fossil remains of hominins spanning the time period that documents the emergence of the genus *Homo*. Equally important is another cradle of humankind located 35 km Northwest of Johannesburg in South Africa, which, over the last 80 years, has yielded a abundant fossil specimens attributed to *Australopithecus*, *Paranthropus* and *Homo* as well as the earliest stone tool artifacts found in the country. These artifacts and fossils are associated with extensive palaeokarst deposits. However, difficulties in dating the cave deposits have contributed led to the perception that the paleoanthropological record from the southern African cradle of humankind are significantly younger than that of eastern Africa, thus limiting the role of the southern African fossil assemblages in the search of the earliest hominin fossils. Recently, the absolute dating of the nearly complete *Australopithecus* skeleton nicknamed 'Little Foot' produced an age of 3.67 Ma [1]. This date, supported by additional stratigraphic and faunal evidence [2], demonstrated that the southern African fossil record may be as old as the eastern African fossil assemblages and specifically has the potential of yielding the earliest evidence of the genus *Homo*. In both areas, fossil hominin remains and artifacts are preserved in geological traps (i.e. the rift valley and caves). Therefore, we may consider the possibility of finding new paleoanthropological sites in other geologically suitable areas in Africa [3]. In fact, the whole continent may represent a potential cradle of humankind, with fossils preserved in natural sediment traps throughout Africa. Based on this hypothesis, the Human Origins in Namibia (HON) research program, represented by an interdisciplinary team, aims to search for fossiliferous palaeokarsts in Namibia. Our promising preliminary results suggest the presence of deep caves acting as sediment traps in several areas in Namibia. Similarly, we initiated a second research project, named Human Origins in Mozambique and Malawi Environments (HOMME), to search for fossil sites in the karsts that surround the southern end of the Great East African Rift. This geomorphologically interesting region provides a unique opportunity to link the Great East African rift sites of East Africa and the karst sites of South Africa. In the first field trip, we found promising fossiliferous breccia which confirmed the potential of this area. If only one early hominin fossil could be found outside the established eastern African or South African 'cradles', this discovery will validate our hypothesis of a greater African cradle of humankind and initiate new research perspectives for interdisciplinary and international palaeoscience teams.

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Carpal modularity in African apes and modern humans

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Several previous studies have analyzed single bones and specific joint surfaces in the wrist with the aim of inferring the functional capabilities that set apart hominins from non-human primates. However, little is known of whether the numerous shape variations in wrist bones are associated or independent with respect to each other. The mutual relationships between bony elements of a single structure are best studied within the framework of modularity as they allow us to know how flexible the evolution of this anatomical region is under differing functional demands. If all carpals behave as a single entity that is tightly integrated by strong interactions, they should comprise a module [1], thus causing wrist bones to covary strongly. Conversely, if more than one module is present in the wrist, this should cause carpals in different modules to vary independently. It is currently unknown how many modules there are in the primate wrist, and how strong the modular signal is. Our analysis intends to address the question of how independent the variation within the wrist is by analyzing the modularity pattern of four carpals (i.e., the capitate, trapezium, lunate, and scaphoid) in a sample of modern humans (*Homo sapiens*), chimpanzees (*Pan troglodytes*), and gorillas (*Gorilla gorilla* and *Gorilla beringei*). 478 3D models and geometric morphometrics were used for this purpose, and modularity was investigated through the testing procedure proposed by Adams and Collyer (2019) [2], known as the covariance ratio effect sizes (Z_{CR} and $\hat{Z}_{12}$).

We tested 15 different modular hypotheses combining all possible partitions of the wrist bones and selected the one that best describes the covariation structure in hominids as a whole, and in humans, chimpanzees, and gorillas in particular. We found that carpals have a great degree of variational independence and in this regard, gorillas, chimpanzees and humans are similar. This might suggest a high degree of independent evolvability in the wrists of hominids. However, the results also indicate that that there is a degree of codependence in the variation of some carpals, which is unique in humans, chimpanzees, and gorillas, respectively. In humans there is evidence of associated shape changes between the lunate and capitate, and between the scaphoid and trapezium. This covariation between lunate and capitate is also apparent in gorillas, while chimpanzees display the greatest disassociation among carpals, showing low covariation values in all pairwise comparisons. Our analysis does not indicate that there is a common covariation pattern for chimpanzees and gorillas, different from that of humans, that could allow us to define a potential knuckle-walking complex. The presence of different modular strengths in the wrist bones of both genera is thus noteworthy, as the presence of a knuckle-walking complex, common to chimpanzees and gorillas, has long been discussed. According to our analysis, what separates humans from African apes is a stronger degree of covariation between the trapezium and the scaphoid. It is interesting that the radial side of the wrist separates these two groups, as a large proportion of studies dealing with manual differences between apes and humans have focused in the trapeziometacarpal and the radio-carpal joints, and point to enhanced manipulative capabilities in the former [e.g., 3, 4,5]. Further analyses should estimate whether the associated changes of these bones are functionally linked to fine manipulation of objects in humans relative to African apes.

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Digital techniques applied to a Neanderthal skeleton still preserved *in situ*: the case-study of Altamura (Bari, Italy)

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Named after the nearest town to the cave site in Southern Italy where it was discovered in October 1993, Altamura is a nearly complete skeleton of an early Neanderthal, dated between 172 ± 15 ka and 130.1 ± 1.9 ka, [1]. The specimen is still preserved inside the Lamalunga cave, covered and partially included in karstic concretions. It is probably the most complete non-modern human specimen ever discovered: a peculiar taphonomic process and the cave microenvironmental conditions determined, in fact, an exceptional preservation of some of the most delicate and fragile skeletal structures. Such conditions required a careful management of the *in-situ* studies that have been allowed so far, before the definition of a protocol for the physical extraction aimed at both *ex-situ* conservation and detailed analyses. The skeleton is several meters below the surface, within a small chamber at the North-Western end of the karstic system – named Abside dell' Uomo or Apse – and in a smaller one beyond it, where some of the bones (including the basal and posterior part of the cranium) are visible using remote-controlled cameras, albeit physically inaccessible.

Hence, since 2017 (following earlier studies from the same research group started in 2009), Altamura has undergone an extensive study in its place of deposition, thanks to a multidisciplinary project financed by the Italian Ministry of University and Research (MiUR), involving an international research group coordinated by one of us (GM). In the context of this research project, techniques of digital acquisition and Virtual Anthropology [2] as well as up-to-date technologies, specifically adapted to the difficult conditions and the microenvironment of the Lamalunga cave, were applied to perform the most thorough assessment of the skeleton and to offer a preliminary reconstruction of some of its anatomical details, particularly for the cranium and the dentition.

Specifically, it was possible to: i) acquire separately the visible portions of the cranium and to align them to obtain a 'virtual extraction', by a specially developed digital tool (DTA, [3]); ii) reconstruct the preserved nasal cavity by photogrammetry, thanks to Olympus endoscopic technology, iii) recognise, by the same endoscopic probes, some skeletal elements otherwise inaccessible due to concretions; iv) perform an *in-situ* X-ray acquisition of part of the dentition and other skeletal elements; v) reconstruct the inaccessible chamber beyond the Apse, by combining photographic and laser scanner data.

Despite the limited access to the specimen, the observations carried out thanks to innovative digital tools and cutting-edge technologies allowed us to shed light on the Altamura skeleton, revealing crucial and hitherto unknown anatomical features of this important paleoanthropological finding.

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The insertion sites of the palmar radiocarpal ligaments in *Australopithecus afarensis*

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One of the topics of greatest interest in human evolution has been knowing the morphology and function of the anatomical structures of extinct species. Postcranial evidence usually indicates that, the species of the genus *Homo* possessed modern anatomical structures that were functionally related to bipedalism. Nevertheless, many studies show that the different species of human lineages have developed their anatomy in a non-linear way. Thus, the anatomical elements of the same individual can present both primitive and modern characteristics.

However, although australopiths were apparently bipeds, their postcranial remains indicate, the morphology of the forelimbs (particularly the wrist and the shoulder girdle) were partially adapted to an arboreal lifestyle. However, the nature of such arboreal adaptations is still unclear, as well as the of arboreal behaviours that australopiths might have engaged in. Therefore, we found extremely interesting to study the distal radius insertion sites of the palmar radiocarpal ligaments in the representatives of the genus Australopithecus, to provide information on the morphology and function of the wrist in these species.

In this study, we used three-dimensional geometric morphometrics (3D GM) to analyse the distal radius ligament insertion sites in two radius bones of *A. afarensis* (AL 288-1Q & AL 288-1V). Their morphology was compared to a wide array of modern hominoidea primates and human taxa: 31 *Homo sapiens*, 25 *Pan troglodytes*, 31 *Gorilla gorilla*, and 15 *Pongo pygmaeus*.

Our results indicate that the morphology of the insertion sites of the palmar radiocarpal ligaments in the distal radius of *A. afarensis* is most similar to the arboreal apes and does not present affinities with *Homo sapiens*. According to our results, the insertion sites of the palmar radiocarpal ligaments in the distal radius of *A. afarensis* shows primitives traits, being more morphologically similar to *Pan troglodytes* and *Gorilla gorilla* (with knucklewalking locomotion) than to *Pongo pygmaeus* (whose locomotion is more arboreal).

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Hip joint loading differences between *Paranthropus robustus* and *Australopitecus africanus* revealed by the cortical bone distribution at the femoral neck

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Given the ability of the cortical and trabecular tissues to respond to the loading environment, the reconstruction of the locomotor repertoire of australopiths (*Australopithecus* and *Paranthropus*) has increasingly integrated information from the inner structure of the appendicular skeleton [1-4]. There has been a particular focus on the internal structure of the hip joint because of its critical role in locomotion. The asymmetrical distribution of cortical bone in the femoral neck, with thinner superior (S) and thicker inferior (I) cortex, has been shown to characterize bipedal humans, reflecting the stereotypical loading of the hip joint. In australopiths, the combination of a human-like S/I asymmetry at the base of neck and a less asymmetric distribution at mid-neck has been interpreted as a commitment to terrestrial bipedalism associated to a slightly altered gait kinematics compared to *Homo* [1,3]. A recent X-ray microtomographic (μCT) analysis of cortical bone thickness distribution across the femoral neck of four *P. robustus* specimens has identified three additional features: (i) a human-like trend of lateral-to-medial decrease in S/I asymmetry; (ii) an accentuated contrast between the relatively thicker anterior and the thinner posterior walls, and (iii) a marked lateral-to-medial thinning of both cortices. However, it is still unknown whether, and to what extent, these features also characterize *Australopithecus*. Given previous evidence for some trabecular variation between *Au. africanus* and *P. robustus* in different skeletal elements [4,5], we predict that a refined assessment of the *Au. africanus* femoral neck cortical distribution has the potential to reveal gait-related differences with respect to *P. robustus*.

Using μCT data (resolution 30 μm), we assessed the cortical bone distribution in two proximal femora from Sterkfontein Caves, South Africa: StW 479 from Member 4 attributed to *Au. africanus* and StW 311 from Member 5, originally attributed to *Au. africanus*, but recently suggested to represent either early *Homo* or *P. robustus* [4]. Both fossils are housed at the Evolutionary Studies Institute and were scanned at the Paleosciences Centre of the Univ. Witwatersrand (South Africa). Due to differences in preservation, we extracted a set of slices at regular intervals from the base (lateral) of the neck to 70% of the total neck length in StW 479 and one at mid-neck of StW 311. We compared their functional signals to the published evidence from the *P. robustus* specimen SK 82 from Swartkrans (South Africa) and 25 extant humans and 8 extant chimpanzees [3].

Our refined S/I measurements of StW 479 support previous CT-based estimates [1]. StW 479 shares with SK 82 a S/I asymmetry in cortical thickness at the base of neck that decreases latero-medially. These features, also observed in extant humans, are thought to reflect habitual bipedal locomotion and the action of the gluteal abductor muscles [1,3]. However, while SK 82 has a less asymmetric S/I ratio than in humans, especially at mid-neck, StW 479 shows a human-like distribution along the neck. In addition, relatively thicker posterior and thinner anterior walls are identified in StW 479, while an opposite pattern is observed in SK 82 [3]. Such differences suggest that the locomotor related-biomechanical environment of the hip joint differs between *Au. africanus* and *P. robustus*, supporting locomotor diversity within the early hominin record. StW 311 shows similarities with StW 479 in cortical bone distribution at mid-neck and differs from the condition in SK 82. Since its trabecular bone distribution pattern at the head is similar to the nonhuman ape condition and differs from the *Au. africanus* pattern [4], further investigation of the trabecular network across the StW 311 neck are needed to help clarify its loading conditions and taxonomic attribution.

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Pleistocene archaeology and tropical paleoecology in West Africa: Preliminary results from fieldwork in Ivory Coast, Benin and Nigeria

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West Africa is the most underrepresented region in the African Pleistocene archaeological and paleoenvironmental record. Few sites have been described, and little is known about Pleistocene environments and hominin behaviour in West Africa. Here, we present preliminary results from archaeological fieldwork carried out at four sites that took place during 2019 and 2020. Anyama (Bété I-IV), Ivory Coast, is an Early Stone Age to Middle Stone Age riverine valley site characterised by Sangoan and proto-Levallois lithic assemblages. With over 15 metres of deposits and several cultural horizons, it is the deepest stratified site within tropical Africa. Tannongou Valley, Benin, is a quartzite ridge depression with two Middle Stone Age sites: Tannongou Cave, a deep-stratified cave with cultural deposits containing previously undocumented Levallois technology, and Paloli, a newly discovered open-air site with a cultural layer of nearly three hectares, with continuous surface lithic scatters and outcrops, and a depth of over 1.5 metres. Iwo Eleru, Nigeria, is a Later Stone Age, Late Pleistocene to Early Holocene granite rock shelter where the oldest human fossil remains discovered in West Africa were recovered. Iwo Eleru is characterised by small-sized flakes and microlithic technologies. By applying novel archaeological, paleoenvironmental and geomorphological techniques, we recontextualize and shed new light on previously known and unknown sites and we offer an array of new interdisciplinary information on subsistence strategies, lithic technologies, and tropical environments of Pleistocene West Africa. These preliminary results serve as a foundation for future research in West Africa, with the final objective of better understanding how this region played a role in hominin evolution, behaviour, and mobility within the framework of Pleistocene Africa. This work was carried out at these localities for the "West Africa's Role in Human Evolution" (aWARE) Project, which is part of the "Pan-African Evolution Research Group" (Pan-Ev) Project.

Fieldwork in Ivory Coast was led by Dr. James Alexander Blinkhorn and fieldwork in Nigeria was led by Dr. Lucy Farr. Geomorphological studies were carried out in Benin by Dr. Ian Candy. We also thank Angelo Ayedoun, Dr. François Yiodé Guédé, Dr. Mateja Hajdinjak, Dr. Emily Yuko Hallett, Dr. Christopher Khiatipes, Prof. Siméon Kouakou Kouassi, Dr. Nestor Labixi and Dr. Pontus Skoglund for their collaboration.

Parturitions, menopause, illnesses and other physiological stressors are recorded in dental cementum microstructure of humans and rhesus macaques

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The life history pattern of recent humans is uniquely derived in many of its aspects including an extended post-reproductive lifespan combined with short interbirth intervals [1]. A number of theories have been proposed to explain the evolution of this unusual pattern. However, most have been difficult to test due to the fragmentary nature of the hominin fossil record and the lack of methods capable of inferring such later life history events from mineralized tissues.

The study of human life history evolution has historically benefitted from hard tissue histology, nonetheless most work has focused on dentine and enamel [2], which cease secretion when tooth completion is achieved [3]. Conversely, cementum is an incremental tissue with post-eruption periodicity, which continues deposition until the death of the individual [4]. Hence, we tested the hypothesis that the physiologically impactful events of parturition, illnesses and menopause are recorded in dental cementum microstructure of two distantly related primate species: *H. sapiens* and *M. mulatta*.

Our sample consisted of: 47 *H. sapiens* teeth (female n=11, male n=36; all permanent); and 41 *M. mulatta* teeth (female n=27, male n=14; permanent n=30, deciduous n=11). All dental specimens were accompanied with life history, medical and lifestyle data. We imaged the specimens using circular polarized light and differential interference contrast microscopy. We detected areas of changes in tissue refractive index related to the optical density rather than material density of the cementum. By calibrating the total cementum thickness with the years of cementum deposition (age of the individual minus age at tooth emergence) we inferred the age corresponding to the observed regions of changes in refractive index. This allowed us to detect reproductive events in all human and macaque females; menopause in all human females; weaning in all macaque individuals in which occurrence was after the age at cementum initiation for the selected tooth. Furthermore, we found that other stressful events such as illnesses and incarceration are also detectable. Histological analysis of the human samples micrographs was carried out manually. Instead, the macaque micrographs were analyzed using custom-developed software routines which enable a semi-automated method of event detection and timing, thus drastically reducing inter- and intra-observer error. Through our analysis we were able to correctly time parturitions, menopause and illnesses in all human specimens (R-squared = 0.92; $p<0.05$) [5] and weaning, parturition, illnesses and traumas in the macaque individuals (R-squared = 0.98; $p<0.05$).

While we are currently not able to discriminate the underlying cause of the histological signature of stress, our work provides evidence that such signatures indeed exist and can be reliably detected and timed. Future research, specifically in the direction of elemental analysis, will likely be able to provide additional information regarding the type of physiological stressors experienced by the individual and recorded in cementum.

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A connectomic hypothesis for the hominization of the brain

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The theoretical hypothesis we wish to propose is based upon a set of biological premises that may be summarized as follows:

1. In less than a few million years, major changes in the neural organization of the brain from the most recent ancestors of man up to *Homo sapiens*, led to a tremendous expansion of its cognitive – psychological - abilities including among others, a very large long-term memory storage capacity, conscious processing theory of mind, and, most distinctively, language.
2. These changes arise in the brain as a consequence of apparently only few genetic regulatory events between humans and other primates [1,2]. They take place within the framework of a common brain organization shared among the primate ancestors of modern humans and already structured on the basis of a rich set of genetic components - or "genetic envelope".
3. The human brain contains vastly more neurons than that of other primates. The increase appears particularly pronounced for the cerebral cortex where it results from an expansion of the number of cortical columns [1].
4. Correlatively the number of cortical areas increases.
5. A scaling up of the multi-level organization of the brain connectome takes place accompanied by a non-linear increase of white matter. The core-periphery network architecture of the primate brain develops in humans to the benefit to the core long-range connectivity of the "global neuronal workspace" [3].
6. Meanwhile in the cerebral cortex a shift of cortical layer reafference from lower to upper layers selectively takes place in humans [4].
7. A unique feature of the human brain is the extension of its postnatal development for up to about 15 years during which the size of the brain increases ca 5-fold. Considerable epigenetic processes of synapse selection [5] and connectomic re-organisation take place during this period. Last a striking cultural diversification of brain connectivity develops between distinct social groups.

The present connectomic hypothesis intends to find a minimal set of principles that allow us to understand human brain architecture in terms of a particular connectomic organization as a phenotype linking the genome and the cognitive levels with major consequences on large-scale network organization and computations of the brain and, ultimately, human cognition, language and culture in the course of its postnatal complexification by synapse selection. The present hypothesis attempts to capture first, the consequence of the absolute increase of brain size and number of neurons within the hominin lineage, and second the deviations from proportional scaling relationships that impose constraints upon human brain connectivity. These unique features would arise, for instance, from self-organization processes, including neuro-modulatory mechanisms, together with intrinsic or environmentally elicited changes of the developing multilevel connectomic architecture of the human brain associated, in particular, with its exceptionally long postnatal epigenetic maturation, Many aspects of this hypothesis need to be substantiated in particular by the identification of the genetic regulatory events engaged in human brain evolution. Our approach may then be seen as some kind of reverse engineering in an attempt to infer the minimum number of "connectomic fundamentals" that parsimoniously account for the intrinsic evolution of the human brain connectome.

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Translating time from transcriptional and structural variation reveals conservation in brain development across humans and chimpanzees

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How the unique capacities of human cognition arose in evolution is an enduring question of interest. Yet, it is still unclear what developmental programs are responsible for the emergence of features unique to the human brain. The inability to find corresponding ages across humans and apes has hampered progress in our ability to detect deviant developmental programs in the human lineage. I use temporal variation in anatomy and behavior as well as dynamic time warping applied to temporal variation in transcription to find corresponding ages from fetal to postnatal ages in humans and chimpanzees. This multi-scale approach provides an unprecedented opportunity to identify corresponding ages across the lifespan in humans and other species.

I collected a total of 136 identified corresponding time points from fetal stages (embryonic day 44) to ~50 years of age in humans and their equivalent in chimpanzees. A linear model on the log-transformed time points accounts for 97% of the variance across the two species. The strong conservation in the timing of these time points permits identifying corresponding ages across these species. I then use these data to test whether developmental programs such as the timeline of prefrontal cortex maturation previously claimed to differ between humans and chimpanzees do so once variation in developmental schedules are controlled for. I compare the growth of white matter pathways from structural MR scans to test whether the growth of frontal cortex white matter pathways is protracted relative to the timing of other developmental programs in humans. I also use an RNA sequencing data-set from the frontal cortex collected at successive postnatal ages in the two species to test whether temporal variation in 19 genes expressed by long range projections (i.e., "supragranular-enriched genes") is protracted in humans relative to chimpanzees once variation in developmental schedules are control for. Contrary to what has been claimed, it is difficult to demonstrate that the timeline of prefrontal cortex development is protracted in humans relative to the timing of other developmental programs. This data-set, which is the largest with which to find corresponding ages across humans and chimpanzees, provides a rigorous approach to control for variation in developmental schedules, and identify developmental programs responsible for features unique to the human brain.

The Effects of Secondary Recycling on the Technological Character of Lithic Assemblages

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Recycling of stone tool artifacts, including both lithic scavenging and secondary recycling, is a widely recognized phenomenon in the Paleolithic archeological record. In some instances, recycling behaviors have produced stone tools with morphological signatures characteristic of multiple time periods or technological systems. These mixed signature types of tools are often used to define transitional industries, including those at the Middle-to-Upper Paleolithic transition. The typical interpretations of these transitional industries invoke hypotheses of technological evolution of Middle Paleolithic toolkits into Upper Paleolithic toolkits due to changing technological/cultural norms through either invention or adoption. In this paper, we test an alternative hypothesis that transitional assemblages formed via secondary recycling of stone artifacts produced by two technologically divergent populations.

Here we use agent-based simulation to implement a simplified theoretical model of secondary recycling in an environment experiencing episodic erosion and deposition to see how these interacting factors might affect the formation of stone tool assemblages. Results from the application of the agent-based model indicate how ordered sets of assemblages resembling archeological transitional sequences can result from the combination of simple recycling behaviors and periods of sediment deposition and erosion. The results imply that some transitional assemblages could have formed without the interaction of different populations and/or without technological evolution. Additionally, this model demonstrates recycling behaviors can produce complex tool characteristics and stratigraphic sequences that complicate chronological relationships between technology types. These results can help generate testable hypotheses for the identification of recycling in the archaeological record. Overall, the results of this paper highlight the need for archeologists to more thoroughly consider how recycling behaviors have affected the formation of the archeological record.

Morphology and maturation of the *Homo naledi* ilium from the Lesedi Chamber

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Homo naledi is known from abundant material from Rising Star Cave in South Africa dating to between 236–335 kya. The ilium of this species is represented by multiple incomplete fragments of different individuals from the Dinaledi Chamber, and one relatively complete immature fragment from the Lesedi Chamber of the cave. An associated fragment including the anterior superior iliac spine refits the Lesedi specimen, making this the most complete ilium for this species. We present new analyses that uncover the state of maturation of this specimen and test whether the australopith-like anatomy previously described in *H. naledi* adult ilia was present from a young age.

To assess stage of maturation, we first measured ilium height at the cristal tubercle in an ontogenetic series of modern humans, the Lesedi ilium, and the only adult preserving this metric in the Dinaledi assemblage. We then resampled immature/adult pairs of humans to obtain proportional size distributions across five maturation stages, which we then compared to the Lesedi/Dinaledi ratio. To examine morphological affinities, we used 3D geometric morphometrics (GM) to compare the shape of the Lesedi ilium to that of immature humans and *Australopithecus africanus* (MLD 7 and MLD 25). We applied 148 landmarks and semilandmarks to the Lesedi ilium, generating separate reconstructions with human and australopith templates. We then performed four separate GM analyses: two including only the landmarks preserved on the Lesedi ilium using either the human or australopith template, and another two analyses including the full landmark configuration, using either template to estimate the landmarks missing on Lesedi.

In our comparison of proportional ilium height, the Lesedi ilium falls into Stage 2 of our five maturation stages, representing a young juvenile individual. The GM analyses are consistent across all landmark configurations, and show that the Lesedi ilium is more similar to *A. africanus* for its thin and flared iliac blade, but more similar to humans for the large absolute and relative size of the auricular surface.

Like much of the *Homo naledi* skeleton, the immature ilium from Lesedi presents an evolutionary mosaic of primitive and derived anatomy. On the one hand, its overall morphology suggests that iliac flare previously noted in *H. naledi* was established early in ontogeny, as has been suggested for australopiths. However, results also suggest that *H. naledi* may have differed from other Plio-Pleistocene hominins in having a relatively larger auricular surface similar to modern humans. We hypothesize that this anatomy is due to differences in either body size, bipedal biomechanics, or the structural reinforcement of the sacroiliac joint compared with other hominins.

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Predictive Modelling and Survey of Karstic Caves in the area of the Inner Asian Mountain Corridor in Kazakhstan

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The Inner Asian Mountain Corridor (IAMC) is an area of foothill and piedmont zones that stretches along the easternmost border of Central Asia, including areas of Kazakhstan. It has been identified as an ecologically rich area in comparison to other, surrounding regions of Central Asia [1]. It is likely that it provided a series of *refugia* during glacial periods, and also a possible corridor for east-west dispersal during the Pleistocene. However, the Pleistocene record of the IAMC in Kazakhstan is overwhelmingly comprised of deflated surface sites. Although a small number of 'open air' sites have been identified and studied in recent years, chronological and environmental understanding in the region during the Pleistocene remains extremely limited.

We present a new method of spatial model-building, and the results of three years of ground survey, identifying caves and rock-shelters in areas of Kazakhstan following the area of the IAMC. We have targeted caves and rockshelters in particular, because the unusual conditions of these features can preserve chronological sequences, fossils, and even DNA, which are unlikely to survive in the arid and deflated areas of the study region. We built two predictive models using supervised and unsupervised methods of landform classification, using the concept of Topographic Position Index (TPI). We then ground-truthed these models through field survey to identify cave and rockshelter features in the region. The second predictive model was generated using results from the field survey led by the first model, which allowed us to increase the discrimination of our model for more targeted field survey the subsequent year. It also allowed us to identify specific landform features as good predictors of cave and rockshelter location in karstic areas. Over the course of our model-led surveys, we identified 95 cave and rockshelter features in Kazakhstan, 30% of which contained some form of sediment. We anticipate continuing to develop the models in the future, specifically aiming to target the subset of cave and rockshelter features that contain sediment accumulation.

In Kazakhstan, we thank Dean Mendigul Nogaibaeva and Prof. Gani Omarov (Faculty of History, Ethnology, and Archaeology,Kazakh National University) for their unwavering support of our project. We would like to acknowledge Dr. Gani Iskakov (Turkestan Museum), now sadly deceased, who joined us in our South Kazakhstan field season in 2018. We would also like to thank our many student volunteers, without whom this work would have been impossible. Finally, we would like to thank our field support staff and the local people who helped us find so many caves. The PALAEOSILKROAD project conducted all field research under license No. 15008746 (12.05.2015) of the National Museum of the Republic of Kazakhstan based on the collaboration protocol between the Eberhard-Karls University of Tübingen and the National Museum. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (Grant agreement 714842; PALAEOSILKROAD project).

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Zooming into the point. ZooMS identification of Mesolithic bone points made with human bone

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Barbed bone and antler points are regularly found washed ashore on the Dutch coast. They were originally deposited in Doggerland and they are attributed to the Mesolithic based on typology and some direct 14C datings [1] [2]. The bones, of which the barbed points were made, have been intensively modified during manufacture, usage and post-depositional processes. Consequently, it is impossible to derive their taxonomical identification from morphological characteristics. In our research we have analysed ten barbed points found on the Dutch shores using mass spectrometry and collagen peptide mass fingerprinting. Here we present the ZooMS taxonomic identifications alongside the results of 14C ages and δ 13C and δ 15N measurements.

- The success of the proteomic analysis of nine out of ten barbed points demonstrates that a burial in marine environments since the early Holocene has preserved sufficient unmodified collagen to allow mass spectrometry-based taxonomic identifications.
- Seven of the analysed barbed points were produced on *Cervus elaphus* and/or *Alces alces* (indistinguishable using ZooMS) bone and antler, while two others were identified as made with *Homo sapiens* bone.
- The uncalibrated 14C ages of the barbed points fall between 9.5 and 7.3 ka 14C BP.
- The δ13C and δ15N values of the human bone points suggest a freshwater and/or terrestrial fauna diet, while the Cervus/Alces bone and antler points fall within the range of other herbivores from Doggerland.

Our study confirms that large-scale application of ZooMS is needed to reveal the selection of species used for bone-tool manufacture during Prehistory. Although our sample is small, it represents a random sample from several sites spanning the entirety of the Mesolithic. In this light we interpret the selection of *Cervus/Alces* and *Homo sapiens* bones as a non-random and intentional choice. The use of human bone for the production of barbed points, which possibly served as weapons, indicates a previously unknown aspect of mortuary practices in Mesolithic Doggerland.

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Automatic detection of sexual dimorphic traits in the human cranium

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Understanding how skeletal elements are influenced by sexual dimorphism in modern humans is crucial to understanding the paleobiology in fossil hominins. The cranial shape is influenced by many factors like sex, age, developmental stage, genetics, pathology and epigenetics. In this communication, we analyze the local variation on the external surface of the cranium due to sexual dimorphism by using a sex-known sample. The detection of sexual dimorphic traits in the human skull is important in anthropological studies to reconstruct the identity of the victims (forensic anthropology), to reconstruct the identity of humans remains buried in archaeological contexts (bio-archaeology) and in general to retrace the lifestyles and society structures analyzed. In literature, the main anatomical traits analyzed in classifying cranial elements are the glabellar region, the orbital shape, the size shape and size of the mastoids and the morphology of the occipital protuberance [1,2]

Here, we report preliminary results on the automatic detection of sexually dimorphic traits in the human cranium by using a geometric morphometric approach. We used a large know sex sample consisting of European and South and North Americans populations of XIX-XX sec.. On each skull we acquired 50 anatomical landmarks distributed on the entire external surface of the cranium. We built a template defining a patch of 1000 semi landmarks. The reference template has been projected and slid on the entire sample of study by using the Morpho R package [3]. We designed in R a bootstrap procedure in which at each iteration we defined a continuous "module" of 15 vertices, and we apply on it a discriminant analysis by using the caret R package [4]. By using this procedure, we associated at each semilandmark an average accuracy in discriminating sex. Subsequently the vector is mapped on a 3D model of the cranium coloring the facets according to the corresponding value of accuracy.

We found that the main cranial sexually dimorphic regions are: supraorbital ridges, occipital protuberance, parietal eminences and zygomatic region. These results are in accordance with previous studies.

In conclusion, the development of an automatic protocol in detecting the sexual dimorphic traits in skeletal elements can be used in physical anthropology to correctly classify sex in large cranial fragments. In perspective, the application of this approach on large repositories of skeletal elements may provide new insights and, maybe in future, provide a quantitative method to detect sexual dimorphism in cranial regions.

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Techno-functional and 3D shape analysis applied for investigating the variability of backed tools in the Late Middle Paleolithic of Central Europe

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In the Late Middle Paleolithic of central Europe, two main cultural complexes have been distinguished: the Micoquian or Keilmessergruppe (KMG), and the Mousterian. Their differences mainly consist in the frequency of some retouched tools and the presence of bifacial technology. When these industries coexist, one element of discussion is the application of different concepts to manufacturing tools with the same techno-functionality. This is particularly true for backed artifacts, such as keilmessers (backed asymmetrical bifacially-shaped knives) opposed to flake-tools equipped with a natural or knapped back. We conducted a techno-functional analysis of the backed tools from the G-Layer-Complex of Sesselfelsgrotte, one of the main Late Middle Paleolithic sequences in Central Europe, characterized by a combination of KMG and Mousterian aspects. In order to better understand the morpho-metrical data, 3D scans were used for recording technical features and performing semi-automatic geometric morphometrics. Results indicate that the techno-functional schemes of keilmessers show a moderate variability and often overlap with the schemes of other typological groups. Particularly in the manufacturing of the cutting-edge, bifacial backed knives went through a process of imitation of unifacial flake tools' functionality. Keilmessers proved to be the long-life, versatile version of backed flake-tools, also due to the recurrent valence as both tool and core. This is why keilmessers represent an ideal strategic blank when a mobile and multi-functional tool is needed. Based on these data, it is assumed that the relationship between Mousterian and KMG is deeply rooted (as summarized in the Mousterian with Micoquian Option – M.M.O. – definition [1]) and the emergence of KMG aspects could be related to constrained situations characterizing the long cold stages of the Early Weichselian. Higher regional mobility caused by the comparably low predictability of resources characterized the subsistence tactics of Neanderthal groups especially at the borders of their overall distribution. For this reason, keilmessers could have represented an ecological solution before possibly becoming a marker of cultural identity.

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Amino acid dating of mammalian tooth enamel and its potential for building geochronologies in Africa

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Directly dating mammalian remains is extremely difficult beyond the limits of radiocarbon dating (∼50 ka). One possible direct dating method is to use the predictable breakdown of proteins and amino acids in biominerals that contain closed-system protein. This has been a powerful tool for Pleistocene age estimation in calcium carbonate biominerals (back to ∼2.5 Ma), but the application of this technique to mammalian remains has been challenging. Our novel method targets a proteinaceous fraction protected within the biomineral crystals (the intra-crystalline fraction), which has alleviated difficulties associated with contamination, leaching and environmental influences.

Through simulated degradation experiments to investigate both the protein breakdown and the intrinsic properties of enamel's inorganic crystal structure, we have found that an intracrystalline fraction of amino acids can be successfully isolated from enamel. The extent of intra-crystalline protein decomposition (IcPD) in proboscidean enamel has been tested against known age material from Britain, Russia and the Mediterranean, showing a strong correlation between extent of IcPD and age. It is therefore now possible to provide direct age estimation for unknown age proboscidean material from the same temperature regions. We are currently expanding enamel IcPD to a range of mammalian species (e.g. bovids and equids) and additional geographic regions including Lake Turkana and South Africa.

The timings and therefore drivers of mammalian evolution in Africa during the Plio-Pleistocene are challenging to determine; usually mammalian material is indirectly dated through association with dated sediment or speleothems. However, the relationship between the mammalian remains and the dated material is not always clear. The Wisdom Teeth project is developing IcPD geochronologies using a variety of mammalian taxa from sites spanning the Plio-Pleistocene in Africa. By targeting sites of anthropological significance, it is hoped that these IcPD geochronogies will provide a framework for human evolution. We are also exploiting the advances in microfluidic technology to develop a "lab-on-a-chip" approach for preparation of enamel samples, with a twofold aim: firstly to reduce sample sizes from ∼30 mg to ∼1 mg, and secondly to allow IcPD dating to be undertaken outside specialist labs. Here we present the latest enamel IcPD data and current progress with the lab-on-a-chip technology.

Clustering Archaeological Evidence: A Statistical View Point

Miguel Angel Dilena

Pioneering automatic methods of tridimensional modelling allow archaeologists to visualise and restore an entire excavation over time. Not only that, but those approaches can also supply a numerical basis to evaluate the whole group of extracted artefacts by using statistical analyses. Such mathematical processes, namely spatial clustering, collects and organises archaeological evidence into volumetric bunches by employing its quantitative and qualitative attributes. Hence, this paradigm can provide researchers with a statistical reference that allows them to categorise each unearthed object into one potential classification (i.e. techno-complex). This method investigates both types of such attributes.

Quantitative attributes, related to 3D physical distances: Accordingly, this attribute represents in a Euclidean sense, distance measures among artefacts [1]. Consequently, the gap between two 3D model centroids i and h (expressed as 3D vectors) is $d(i,h)$ [2].

Qualitative attributes, connected to association measures among evidence: This analysis defines, to some extent, if there is a discrepancy concerning:

- flaking techniques,
- the manufacturing process (technology),
- kind of raw material utilised,
- typological diagnosis,
- refit components,
- heated elements,
- reworked materials.

Therefore, such an evaluation shall create a qualitative table (vector) that describes the absence or presence of the previous attributes in every binary association of artefacts. Moreover, through this table, a coefficient of distance can be calculated. The highest association distance represents the lowest coefficient estimation. This association measure indicates a qualitative gap between two elements i and h: $a(i,h)$ [3].

Afterwards, a weighted 3D vector (wm) combines both distance, dm, and association, am, measurements to consider both quantitative and qualitative attributes:$wm=f(dm, am)$. Weighted measurements related to each archaeological element, are merged into a composite matrix that constitutes the input information that goes to a hierarchical clustering algorithm [4]. The resulting outcome contains bunches of archaeological 3D models aggregated by clusters that statistically show a high level of correlation among them.

A volumetric 3D plaster that represents the stratigraphy of the excavation (layers, units, and their tridimensional position) can correlate the goodness of fit and adequacy of this model by employing statistical multivariate distance assessments. hence, a stratigraphy's plaster should entirely contain the archaeological 3D cluster; otherwise, this appraisal could reveal possible outliers and detect plausible geological or archaeological anomalies [5].

From this perspective, this process becomes iterative by taking into account two crucial elements. Firstly, the use of alternative coefficients to calculate the weighted measurement. Secondly, the employment of a visual correlation between 3D cluster models and the 3D plaster model.

In conclusion, this methodology supplies archaeologists with mathematical tools to study the complete excavation by using statistical analyses and visual correlations.

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New evidence for the emergence of early Acheulean Technology at Kokiselei 6 in West Turkana, Kenya

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We present new evidence for precursors of early Acheulean technology from the Kokiselei Site Complex (KS) in West Turkana, Kenya, at the Kokiselei 6 (KS6) site. KS6 provides a rare opportunity to investigate processes of technological change during the emergence of early Acheulean technology because it just slightly predates the earliest known Acheulean site of Kokiselei 4 (KS4), situated in the same complex. Thus, the KS complex preserves both late Oldowan and early Acheulean lithic technology in a well-defined chronostratigraphic framework. The development of 'shaping' (e.g., biface production) in lithic technology, associated with the emergence of the early Acheulean, is often used as evidence for increased and/or novel cognitive abilities that contrast prior hominins' flaking capacities [1]. Recent research from eastern Africa reveals a story of gradual change over time during the emergence of the earliest Acheulean technology which included a variety of different flaking and shaping strategies [2].

Here, we directly examine the emergence of early Acheulean technology at KS6 and present results that significantly contribute to our understanding of Early Pleistocene processes of technological change. KS preserves the oldest known Acheulean lithic assemblage, KS4 (1.76 Ma), as well as several other archaeological localities from the Oldowan [3]. The KS6 site was discovered in 2005 and excavated in multiple seasons between 2005-2007 by members of the West Turkana Archaeological Project (directed by S. Harmand). KS6 is well-understood in the local chronostratigraphic framework to be slightly older than KS4 (1.8 Ma). The excavation at KS6 yielded two distinct layers of finds that included thousands of lithic artefacts and faunal remains that were piece-plotted. This rich and well-preserved new site presents an opportunity to chronologically investigate processes of technological change during the development of shaping strategies with the earliest biface production within a single site complex. H. Duke completed a technological analysis of all artefacts (n = 3,865) in the KS6 lithic assemblage that displayed clear knapping traces and that focused on understanding variability in knapping strategies. The results of this analysis show a strong emphasis on bifacial flaking strategies that used smaller raw materials in comparison to those published for KS4 and for the Oldowan site, KS5 [4]. The appearance of biface production is minimal, and extensive shaping is not present in the KS6 assemblage. However, the technological processes behind the production of these bifaces is similar to strategies demonstrated in biface production at KS4 [5]. We argue that biface shaping emerged gradually out of variability in bifacial flaking strategies during the earliest emergence of the Acheulean at KS. These conclusions call into question theories of hominin cognitive evolution that suggest Acheulean technology required new, and more complex, cognitive abilities. Instead, our results suggest that the cognitive abilities necessary for biface shaping were likely already present in bifacial flaking strategies that had deep roots.

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Multi-Analytical Study of Quartzitic Outcrops at Oldupai Gorge (Tanzania): Implications for Artifact Sourcing

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Oldupai Gorge (Tanzania) was an endorheic lake basin supplied by fluvial systems stemming from the Ngorongoro Volcanic Highlands, and characterized by metamorphic inselbergs associated with the Mozambique Belt. Oldupai's archaeological record exhibits a sequence of lithic assemblages associated with the Earlier, Middle, and Later Stone Age which were predominantly manufactured from quartzite. While technological change is perceptible, the suite of locally available lithologies remained relatively constant through time. However, limited efforts have been devoted to studying quartzitic outcrops for the purposes of artifact sourcing under the assumption that these are homogeneous from a macroscopic, petrographic, or geochemical perspective. Here, we present our multi-analytical characterization project of quartzitic outcrops in the Oldupai region based on field mapping, and a combination of hand specimen classification, thin section petrography, SEM, EPMA, and ED-XRF spectroscopy. Statistical analysis (PCA, DA, FA) of the geochemical data reveal that there are inter- and intra-outcrop differences, and some unique elemental fingerprints [1, 2]. Comparative analyses of mineralogical and textural data reveal that some outcrops bear quartzites that are differentiable from one another [1, 3]. We are able to best differentiate source lithologies using geochemical and petrographic data, but have limited success using macroscopic descriptors. Overall, our results support the feasibility of sourcing lithic artifacts on a basin-wide scale, which we demonstrate by assigning the source/s of unpublished and previously described [4, 5] fuchsitic quartzite artifacts from HWK EE and LK (Oldowan), EF-HR, FC, HK, JK W, TK, and VEK (Acheulean) to two outcrops known as Naibor Soit Kubwa and Naibor Soit Ndogo. These preliminary results indicate that Oldowan and Acheulean toolmakers in the eastern paleobasin procured fuchsitic quartzite from the same outcrop/s <2.5 km away throughout the deposition of Bed I, II, and III. Our open-access reference collection will serve as a comparative tool for systematic archaeological testing to develop new models of hominin behavior at Oldupai Gorge, contextualized by additional research undertaken as part of the interdisciplinary *Stone Tools, Diet, and Sociality at the Dawn of Humanity* project (https://olduvaigorgesds.com/).

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Pattern of phalanx flexion during Lower Paleolithic tool haptic exploration

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Size is a pivotal factor in ergonomic design, and affects the finger joint angles of flexion. Also in lithic technology, form, size and shape do influence the ergonomic properties of a tool [1]. When compared with extant apes, modern humans have evolved hands that allow specialized grasping patterns, probably in association with tool use and production [2]. In this sense, haptic exploration can supply information on biomechanical aspects of hand-tool interaction, but also on human-specific cognitive aspects of the relation with tools [3]. Experimental studies in archaeology suggest that the form of Lower Paleolithic stone tools influences the grasping responses associated with their use [4].

Here, we investigate the relationship between Lower Paleolithic stone tool dimensions (20 Oldowan pebble tools and 20 Acheulean handaxes) and the comfortable grasping of these tools types. Eighty-two subjects participated in the study; they had no prior knowledge on lithic or archeology, and they were asked to find the most comfortable way to grasp each tool. We use a VMG 30™ motion capture hand glove to record the position of each finger digit at each finger joint associated with the final resting position. A linear regression analysis is used to highlight how much the tool physical dimensions can predict the pattern of finger flexion. For pebble tools, only maximum length is a significant predictor of grasping scheme, while for handaxes maximum length, thickness and width are all good predictors for comfortable grasping. In conclusion, the haptic experience differs for pebble tools and handaxes when ergonomic feedback is taken into account. This suggests different biomechanical responses and, according to the principles of haptic exploration and technological extension, possible cognitive difference in body-tool sensing. Tool morphology and other physical features of the tool may also play a major role in the cognitive perception of the tool and in the integration of the tool into the body schemes [5].

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A systematic colourimetric method for identifying heated substrates in archaeological sites

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In human evolution, the use and control of fire is a topic that has ignited research for several decades. The recognition of archaeological fire features relies mainly on the identification of fire by-products (such as ash and charcoals) and burned components (such as bones or lithics). However, preservation of such evidence can be limited in the archaeological record, with burned remains being displaced from their original location both by natural processes and by human actions such as intentional hearth rake-out and dumping. The identification of intact heated inorganic substrates is, in contrast, a good indication of the exact placement of where a past fire was originally lit [1]. The most evident and usual signal of burnt sediments is colour, which is normally assessed by the naked eye using the Munsell Colour Chart. Since fire oxidizes Fe minerals towards the production of hematite, a mineral that has an intense red colour [2], red layers are often interpreted as burnt layers. Such visual assessment of colour is flawed by a heavy dependence on the operator subjectivity, as well as on environmental conditions, and provides no conclusive information on heating temperatures and duration.

In this work, we get insight into the potential of colour as an indicator of heated sediments and as proxy for diagnosing heating temperatures. With these aims, we addressed the instrumental characterization of colour using the CIELab system on a diversity of soils and sediments from natural and archaeological settings. We assessed the different patterns of colour developed upon heating at different temperatures (at 100, 200, 300, 400, 500, 600, 800 and 1000ºC during 6 hours) and durations (heated at 600ºC during 10, 30, 60, 180 and 360 min). We characterized the chemical, thermogravimetric and mineralogical properties of the samples and employed multivariate statistics (principal components, hierarchical cluster and discriminant analysis) for diagnosing if sediments have been heated or not and to which temperature, thus setting the foundations for a systematic colour-based fire identification methodology usable in field and laboratory. Concerning the discrimination between Heated-Unheated classes, our methodology has allowed to correctly assign 89.5% of the samples. Of the unheated samples, 98.4% of 159 were classified correctly. Of the heated samples, 84.6% of a total of 318 cases were correctly assigned. The 49 cases incorrectly classified as Unheated correspond to lower heating temperatures (at 300º C treatment) and, to a minor extent, to calcareous sediments exposed to high temperature treatments (800 and 1000º C). A second discriminant analysis using sample subpopulations defined according to their chemical properties provided a fairly accurate classification of the samples in heating classes (from 0 to 1000º C). However, the predictive capacity of this method only stands if the sample group being considered is chemically and mineralogically homogeneous, and is lower when the sample set is heterogeneous. The use of this methodology thus requires the chemical and mineralogical characterization of the target soils and sediments in order to achieve a reliable assessment of the presence of fire and temperature of heating.

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Patterns of sex differences in the pelvis did not evolve *de novo* in modern humans

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The pelvis is the only part of the human skeleton for which females have larger average dimensions than males. Compared to males, females have larger birth-relevant dimensions of the pelvic canal and a wider subpubic angle as well as a wider sciatic notch. This makes the human pelvis the most reliable anatomical structure for sex determination of skeletal remains. In this study, we present new results that shed light on the evolutionary origin of these sex differences. We conducted a geometric morphometric analysis of individual pelvic variation in modern humans and chimpanzees (*Pan troglodytes*). Our study sample comprised 34 adult chimpanzee pelves (20 females, 14 males) and 99 adult human pelves (53 females, 46 males). On each pelvis, 109 3D landmarks were collected (44 anatomical 3D landmarks and 65 curve semilandmarks). Based on a joint analysis of all 133 pelves, we quantified similarities and differences in pattern and magnitude of sex differences in humans and chimpanzees. Surprisingly, the *pattern* of pelvic sex differences was almost identical despite large species differences in overall pelvic shape. The *magnitude* of pelvic sex differences, however, was twice as large in humans compared to that in chimpanzees. Based on these results, we conclude that the pattern of sex differences in the human pelvis did not evolve *de novo* in modern humans but that it represents a homology between humans and chimpanzees and must have been present in the common ancestor. To explain the parallel patterns in humans and chimpanzee pelvic sex differences, we propose a "facilitated variation" hypothesis (referring to the concept of facilitated variation in evolutionary developmental biology [1]). We suggest that the genetic-developmental machinery underlying the pattern of pelvic sex differences has stayed relatively conserved during primate and probably even mammalian evolution. But the regulatory switch behind this machinery, which determines the magnitude of pelvic sex differences, has high evolvability and adapts rapidly. We propose that this switch relates to the amount and duration of estrogen and relaxin secretion as well as to the overall reactivity of the corresponding receptors in the pelvis. Our hypothesis provides the testable prediction that the pattern, but not the magnitude, of pelvic sex differences is largely conserved across primates and non-primate mammals, despite very different obstetric and biomechanical requirements.

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Evolutive challenges in Gravettian diet. Experimenting the processing of oat

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This experimentation is a part of the research project "PLUS_P", dealing with the technologies for plant food processing documented by stone tools with use-wear traces and plant residues found in several European sites that can be referred to the Gravettian and dated around 30,000 years ago. The great variety of plants processed and tools used illustrates the adaptation to different economic and environmental contexts of a technology that must have been fairly common and widespread all over Europe [1]. This capacity for complex plant processing could be part of a Mid-Upper Palaeolithic behavioural package, with all the deriving consequences for diversified subsistence strategies and demographic changes. The experimentation here presented is related to the processing of oats, as recorded on the pestle-grinder discovered at Grotta Paglicci (South Italy) [2], where starch grains of wild oat (*Avena barbata*) were recovered.

The inhabitants of Grotta Paglicci were the most ancient population to use a method that involves at least four successive steps in preparing plants for consumption, from harvesting to cooking. Specific experimentation was designed to check the methods of this recently discovered multistep-processing. In order to replicate this process, it was developed a protocol which involved the use of suitable plant material (*Avena barbata* and *Avena sativa*) and the necessary tools, with morphometric characteristics similar to the Paglicci pestle. The experimentation made it possible to confirm certain hypotheses previously made in relation to the features of the oat starch grains found on the Paglicci pestle, in particular the performance of a heat treatment of the caryopses before grinding.

The heat treatment could be the solution to the problem of threshing and dehusking of *Avena barbata* through the combustion of the dry ears: in fact, the heat treatment causes the combustion of the glumes. In addition, it facilitates the grinding/pounding of the toasted caryopsis, prevents the oxidation of the lipids and develops the specific flavour absent from oats harvested from the fields. This experimental study demonstrated the high level of cognitive and technological skills of first Gravettian populations, who processed and consumed one of the few cereals available in Europe at the time.

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Continuity and Change in Hominin Technological Behavior at Tabun Cave, Israel

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Tabun Cave has long been a major point of reference for the Lower and Middle Paleolithic of the Levant because of both its long sequence of cultural deposits, 25 meters in depth, and its rich and variable artifact assemblages. Roughly a third of the Tabun sequence contains Lower – Middle Paleolithic assemblages referred to as Yabrudian, Acheulean, and Amudian. Together, these three facies comprise the Acheulo-Yabrudian (AY) complex, or Jelinek's [1] Mugharan Tradition. Much work on these assemblages focused on distinctions between these facies based on relative frequencies of recognizable tool types: scrapers, blades, and bifaces present in varying frequencies within each. This study instead examines metrics and attribute data for one artifact class, side scrapers, shared by all three facies. The goal is to compare variation in artifact production and life histories in a single type of artifact across the AY. The study sample consists of sidescrapers from four stratigraphic beds representing all three facies. Because they are typically well represented, the scrapers should be an excellent measure of the degree of technological continuity/discontinuity throughout the AY. Because no dominant scraper types were previously identified in these assemblages, Jelinek [1] believed the scrapers reflect a single, internally consistent industry that underwent gradual change. This study further investigates this interpretation.

Results reveal broadly consistent scraper manufacture between all beds and support Jelinek's notion of cultural continuity with gradual change through all AY facies. Few scraper measurements are strongly correlated within or across samples, indicating limited morphological standardization. Attributes related to cortex and dorsal scar patterns also vary little among the beds. While the general structure of scraper production and design remained unchanged, the chaîne opératoire was altered somewhat. Variation in scraper reduction, size, and shape is noted, potentially reflecting subtle differences in manufacture not captured in attributes such as blank or dorsal scar pattern frequencies. During the earlier Yabrudian, Tabun hominins manufactured smaller blanks that underwent less retouch and resharpening. In the subsequent layers, Acheulian and Amudian, they produced larger blanks with more available edge area to retouch. Additionally, use lives of the scrapers suggest that tool longevity was further extended during the later layers than in the earlier Yabrudian, where only one scraper edge was typically retouched. It became common, perhaps necessary to make more efficient use of scrapers, in these later periods. This research significantly contributes to the study of hominin evolution and has broad implications for human cognitive ability and technical know-how. These results suggest that at 300-400 ka hominins shared high levels of continuity in basic production, but flexibility in adjusting to economic or logistic circumstances (life histories) in both meaningful and measurable ways.

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A functional analysis of Carabelli trait in Australian Aboriginal dentition

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Carabelli is a non-metric dental trait that can be found on both second deciduous molars and first permanent molars, ranging from a small pit to a prominent cusp. The degree of expression and frequency of this accessory trait in modern humans can vary individually and across populations, which suggests a strong genetic basis [1]. Due to its capacity to vary at many levels of expression, Carabelli trait has been frequently employed in anthropological and archaeological studies for reconstructing phylogenetic relationships, population affinities and for the determination of individual identity, such as ethnicity, gender and age. However, whilst emphasis is placed on the formation and expression frequencies of Carabelli trait, little evidence exists on its functional attributions to mastication. In this study, we examine molar macrowear with the aim of reconstructing Carabelli trait occlusal dynamics occurring during mastication using Occlusal Fingerprint Analysis (OFA), a quantitative digital approach that can be used to reconstruct the jaw movements of an individual by examining the molar macrowear patterns [2]. Here, we explore the functional implication of Carabelli trait in the dentition of children and young adults from Yuendumu, an Australian Aboriginal population that was at an early stage of transition from a nomadic and hunter-gatherer way of life to a more settled existence [3]. We analysed permanent and deciduous molars of upper and lower arches with a slight to moderate degree of wear, based on dental stone casts showing the presence of Carabelli trait in occlusion (N = 96), with age groups ranging from 7.05 to 34.53 years of age. We also considered the degree of expression of Carabelli trait by using the Arizona State University Dental Anthropology System (ASUDAS), a standardized system consisting of a series of rank-scale plaques used to assess dental morphological (or nonmetric) variation in human populations [4]. Our results demonstrate that Carabelli trait slightly enlarges the surface functional area, especially in those molars where this feature is expressed in its cuspal form and it is closer to the occlusal plane. Moreover, the highly steep contact planes would also indicate that Carabelli wear areas contribute in increasing shearing abilities, which are particularly important when chewing fibrous and tough foods [5]. Overall, the macrowear analysis suggests that Carabelli trait in the Aboriginal people from Yuendumu slightly enhanced occlusion and likely played some functional role during mastication. Future biomechanical and microwear analyses could provide additional information on the mechanical adaptation of Carabelli trait in modern human dentition.

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Emorph Project: Reconstructing mobility patterns of *Rangifer tarandus* during the Late Pleistocene in Southwestern France

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Palaeolithic reindeer (*Rangifer tarandus*) played an important role for human populations in Western and Central Europe during much of the Palaeolithic period, particularly during the Magdalenian [1], and hence many studies have focused on it. Their movements are key to understanding human hunting strategies and mobility of human groups during that period , since the mobility of an animal will affect human resource scheduling strategies .However, and despite the numerous attempts to reconstruct the migratory behaviour of Palaeolithic reindeer, there is no clear model of reindeer migration routes.

Modern ethological data indicates that reindeer herds adopt different mobility strategies that correlate with habitat type and topography [2]. Furthermore, it has been demonstrated that an animal's habitat and mobility patterns hypothetically affect bone density and limb bone morphology as has been proven in several species (e.g. bovids or horses) [3].

Due to the fact that modern reindeer herds still exist in woodland, mountain and tundra settings, it is possible to create a referential framework to study ecomorphological differences between animals from different biomes and with different mobility patterns.

Therefore, the main goal of Emorph Project is to quantify the relationship between mobility and morphology using modern reindeer (caribou) populations and then to apply the resulting referential framework to faunal assemblages from Upper Palaeolithic archaeological sites in South-western France to reconstruct reindeer mobility.

Metacarpals, metatarsals and phalanges from six modern reindeer populations from different settings and degrees of mobility have been studied through the use of Computer Tomography (CT), Geometric Morphometric Methods (GMM) and linear measurements. For GMM analysis, five sections (to take into account the fragmentary nature of bone remains) 20%, 35%, 50%, 65% and 80% of the total bone length for metapodial bones and one for the phalanges (50%) have been scanned to perform shape analysis. As a result, linear measurement analyses show high rates to predict membership according to mobility degree. However, Geometric Morphometric and Linear Discriminant Analyses (LDA) show how it is possible to distinguish mobility degree and predict group membership more accurately having percentages which range between 80% and 98%, depending on the section and bone type. In the case of metacarpals, the transversal section which allows the best discrimination between different mobility degrees, with a 98,33% of success, is the 20%, followed by 65%, 35%, 50% and 80% sections.

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Dental morphological analysis of Holocene Iberian populations: the utility of enamel dentine junction in population dynamics

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Farming was one of the most significant events in human history, driving major biological and cultural change globally. The peasant way of life arrived in the Iberian Peninsula (IP) about 7500 years ago, during the Early Neolithic [1]. It was a relatively fast process that affected both the interior and coastal zones, but it was also a heterogeneous process with different impacts of incoming populations on the genomic and cultural diversity. During Middle to Late Neolithic transition, in Northeastern of IP (NE-IP), changes in the funerary practices (individual to collective burials), settlement patterns and cultural material (Veraza and Bell-Beaker sets) occurred [2] [3], together with a decrease of genomic heterogeneity, which continued during the Bronze Age, and thus suggesting human mobility and genetic admixture between different Iberian populations [4] [5]. Dental morphology has been successful when differentiating several hominin species, as well as for establishing biological relationships and affinities between ancient modern human groups, migration and adaptive patterns. But, surprisingly, less attention has been paid to the morphological traits of dental inner tissues in modern human and its utility for Holocene population dynamics studies. Here we apply a 3D geometric morphometrics approach to explore dental morphological affinities of NE-IP populations from Neolithic to Bronze age. Specifically, individuals from Can Sadurní, Cova de Les Agulles, Cueva de El Mirador, Cova de la Guineu, and Cova dels Galls Carboners sites. Our goal is to detect dental morphological changes through approaches traditionally employed in human evolution studies. The enamel-dentine junction (EDJ) of maxillary first molars, obtained from micro-CT scans, were used and their morphological variability and affinities were examined among the samples. Dental morphology was characterized by a configuration of landmarks and semilandmarks for describing occlusal and cervical traits. Our results show that EDJ morphology can significantly (MANOVA, $p<0.05$) discriminate between Neolithic and Chalcolithic NE-IP populations, with an overlap of dental morphologies for Chalcolithic and Bronze Age sites. Cervical outline in isolation also differentiates significantly between individuals from different time periods. Similarities in dental morphology during Late Neolithic-Chalcolithic periods from different areas of NE-IP also confirms genetic admixture suggested by paleogenomic studies, as a result of human mobility and exchange networks. These results highlight the utility of the EDJ morphology as a genetic proxy in Holocene population dynamic studies when paleogenomic studies are absent, as well as to detect evolutionary changes that still occur in our own species at small scale.

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The use of quartz during the late Upper Palaeolithic of central Portugal

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Quartz has traditionally been regarded as a raw material of lesser/poor knapping quality. Indeed, the structure of this mineral determines the presence of cleavage planes which generate fractures and influence débitage. The fact that it is naturally available in regions where there is no flint or silcrete, however, resulted in its frequent exploitation by the Palaeolithic human communities that inhabited the Portuguese territory. An outstanding example is the preferential use of this raw material for the production of marginally backed bladelets during the Protosolutrean of Estremadura [1]. Moreover, at sites located in the Hercynian massif (Guadiana, Sabor and Côa river valleys), several different varieties of quartz constitute the most widely used lithic raw materials during the Upper Palaeolithic [2,3,5]. Furthermore, at sites located in the Lusitanian basins (Estremadura and Algarve) and despite the availability of flint, quartz (along with quartzite) is always present in the Upper Palaeolithic lithic assemblages [2]. Considering the recurrent exploitation of quartz in different regions, its study is particularly relevant, enabling an inter-regional comparison that broadens our understanding of the cultural variability of Upper Palaeolithic communities.

The present research focuses on comparative data on the use of quartz in the Côa Valley (Fariseu and Cardina) and the Vouga Valley (Vau and Rôdo) sites. The work carried out since the identification, in 1995, of the first human occupation contemporaneous with the Côa Valley Palaeolithic engravings resulted in the accumulation of data on raw material procurement and on the production and use of lithic artefacts. As a result of the surveys carried out in this region, a number of different types of quartz could be sourced [3]. In 2014, as part of the Ribeiradio-Ermida river dam archaeological mitigation works, the first sites featuring Upper Palaeolithic occupations in the Vouga Valley were identified and excavated [5].

Furthermore, the lithic assemblages recovered from the Rôdo and Vau (Vouga) and Cardina and Fariseu (Côa) archaeological sites featured both free-hand/not supported and bipolar/supported on-anvil quartz cores. In the absence of cores, it is sometimes possible to recognize the application of these knapping strategies, based on the presence of characteristic flakes, fragments and chips. Assigning splintered pieces a use as cores or as tools is a problematic issue inherent to this type of assemblages [4].

Bipolar débitage on anvil, for the production of small flakes or chips, was used in these two regions since the Gravettian [2,3,5] and can still be found in Magdalenian and Azilian assemblages [4]. This strategy has been interpreted as an attempt at improving the profitability of raw materials; its use over a long period of time does not allow it to be used as a chronological indicator. The use of hyaline quartz crystals, using the natural planes of the crystals, for the production of bladelet blanks has also been documented in these two regions. Transformation of blanks, however, is still unclear because the available data only support comparisons between tools on flake, since the quartz armatures recovered at the Vouga sites are quite rare.

The volume of data on the two areas being compared is uneven and we have little information on the technical tradition and functionality of the Vouga sites. There is, however, enough information to compare and identify, in these archaeological sites located in two different regions, the same conceptual scheme inherent to the chaîne opératoire applied to the different types of quartz.

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Evolutionary development of the *Homo antecessor* scapulae (Gran Dolina site, Atapuerca) from a 3D geometric morphometrics approach

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The study of scapular morphology has had an important impact on the study of human evolution from both functional and phylogenetic perspectives [1]. Moreover, it is critical to understand scapular ontogeny (growth and development), since evolution occurs via genetically conserved developmental variations. This issue has been well-documented in the scapular morphology of extant primates, but the scarcity of the scapular fossil record poses a serious challenge to understanding the scapular ontogeny of extinct hominins. Recently, two well-preserved, 800ky scapulae from Atapuerca attributed to Homo antecessor were described: ATD6-116 is purported to have been a young child, whereas ATD6-118 is thought to have been an adolescent [2]. This material provides a unique opportunity to investigate shoulder girdle evolution and address growth and development trajectories in a Lower Pleistocene human species. To evaluate the ontogenetic trend of *H. antecessor*, we investigated scapular morphology in a sample of 98 *Pan troglodytes* and 108 *Homo sapiens* from ontogenetic stage 1 (deciduous teeth not fully erupted) to stage 7 (full permanent dentition). We also compared the ATD6 scapulae with the scapulae from Dikika [3, 4](*Australopithecus afarensis*; similar in age to ATD6-116), Nariokotome (*H. ergaster*; close in age to ATD6-118), and Malapa [5](MH2, A. sediba; adult female). Missing data estimation, when necessary, was carried out through a partial least squares approach following previously suggested protocols. We performed a Procrustes analysis to derive novel shape variables, which were regressed against centroid size to derive the slope of the different ontogenetic shape trajectories. ATD6-116 is slightly larger than the Dikika scapula, and both are between developmental groups 2 and 3 of *Homo* and *Pan*. ATD6-118 is about the same size as MH2 and slightly smaller than Nariokotome. Developmentally, *P. troglodytes* and *H. sapiens* differed in both their regression scores and slope of their trajectories. *P. troglodytes* had the highest positive regression scores, relating to relatively narrow scapulae with a more cranial orientation of the glenoid fossa and the acromion. Alternatively, *H. sapiens* had more negative regression scores, with mediolaterally broader scapulae and laterally oriented glenoid fossae. Both *H. antecessor* and *Australopithecus* trajectories present slightly more positive values than modern humans, but are distinct from *P. troglodytes* of the same size with an ontogenetic trajectory closer to that of humans, both in terms of distance and slope (*P. troglodytes*=0.0013; *H. sapiens*=0.0018; *Australopithecus*=0.0021; *H. antecessor*=0.0021). The fact that both fossil hominin taxa share a similar ontogenetic trajectory to one another and modern humans suggests that scapular development in *Australopithecus* and *H. antecessor* was already modern human-like – though, importantly, there are several morphological features that distinguish them from modern humans along the entire trajectory. We also note that the *Australopithecus* specimens studied here (DIK-1-1 and MH2) are assigned to different species and span an expansive range of chronology and geography. Accordingly, validation of this trajectory will require the inclusion of additional specimens (e.g., the adult *A. afarensis*, KSD-VP-1/1 or the juvenile MH1 *A. sediba*). All told, the preservation of two fairly complete, subadult scapulae, likely belonging to the same Lower Pleistocene population, provides a unique opportunity to study evolutionary development of the hominin shoulder girdle. We purport that by ~800ky, archaic hominin shoulder development was already trending towards that of modern humans.

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Metagenomes and ancient human lineages from a pre-LGM layer of Satsurblia cave in the Caucasus

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Recent studies recovered multiple mitogenomes of various *Homo* lineages and other mammals from Late and Middle Pleistocene from archaeological sediments [1]. This approach opens a new horizon for the study of human evolution, admixture history and dispersals as either a complementary or an alternative approach to paleogenomic studies of human remains. It also holds the potential to provide new inforrmation about past environments, and human subsistence and behaviour.

Here we present genomic data from sediment from an Upper Paleolithic occupational level of Satsurblia cave, Imereti region, western Georgia, dated to 25, 000 years before present (bp).The site has yielded a rich archaeological record for Upper Palaeolithic occupation which spans from 33,000-14,000 years before present [2]. A previous study of a complete human genome from a human right temporal bone from this site, dated to the Late Upper Palaeolithic (13,132–13,380 cal bp) [3], showed that the post-LGM population which inhabited this region, were 'Caucasus hunter-gatherers' (CHG), a main source population for several Eurasian populations. However, the genetic composition of the pre-LGM inhabitants of the region remains unknown as there are no genomic data for this period for Western Eurasia.

We report the recovery and analysis of a human mitochondrial genome with clear genetic affinity to Bacho Kiro mitogenomes from Bulgaria, dated to 45,000 years bp [4]. The analysis of the nuclear genome shows that the recovered human data does not cluster with the previous reported genome from Satsurbila Cave, in contrast it appears to be close to the present-day Levant populations. This results evidence of genetic discontinuity during the LGM in the Southern Caucasus region.

Additionally, in the same layer we have also identified the presence of three other mammal species: *C. lupus, B. taurus* and *Ovis* species. The genomic comparison of these lineages revealed relevant data on the evolution of these species as well as the interaction between humans and human-related species.

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The development of bite force resistance in modern humans

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Differences in cranial form among individuals within species and between species are accentuated by postnatal growth and development. During the postnatal period, crania change in size and shape through displacements of bones at sutures and synchondroses and by remodeling of bony surfaces. Further, the cranium is loaded by forces applied to the masticatory system in feeding and manipulation and these forces change over time as diet (e.g. weaning) and paramasticatory behavior change. As the cranium develops and grows, we might expect deformations and so strains to change accordingly, resulting the cranium adapting to these altered strains. Differences in form among developing crania might be expected to both arise from and influence the distribution and magnitude of strains experienced during masticatory system loading. Such differences might underlie the distinctive distributions of facial remodeling fields in modern humans and Neanderthals and differences in craniofacial growth. To better understand how masticatory system loading interacts with craniofacial growth and development in modern and fossil hominins detailed studies of craniofacial ontogeny, and the ontogeny of bite force resistance are required.

The present study explores the ontogeny of human biting resistance as a preliminary to assessing the association between this and facial remodeling among hominins. A regression based model of modern human craniofacial growth and development is used to create mean infant, juvenile and adult finite element models that simulate biting. Our hypothesis is that modes and magnitudes of cranial deformation vary in a consistent manner among these three models, derived from a single linear regression.

We used a virtual ontogenetic series of 63 modern human skulls ranging from birth to adult, from a population of European ancestry. Using 40 landmarks and 212 semilandmarks we carried out a linear regression of cranial shape on size. Three surfaces representing the mean infant, juvenile, and adult stages were extracted from this regression. These surfaces were then converted into finite element models, and then constrained and loaded in a standardised way to simulate right first incisor and P4 or dm2 biting which were then solved in finite elements analyses. Applied forces and material properties were identical among models to control for all variables except craniofacial form. We compared the resulting deformations, maps of von Mises strains and bite forces among crania.

The resulting deformations differ in both mode and magnitude among models. In both incisor and molar biting simulations, strains generally decrease between infancy and adulthood as is to be expected given the differences in size among models. However, in the facial skeleton, there is a moderate increase in strains in localized areas between the infant and juvenile, with a subsequent reduction in strains in these regions in adults to below the levels found in infants. These findings falsify the hypothesis and raise some interesting questions. Why should the larger juvenile face show localized regions of increased magnitude and why do these strains then reduce in adults? These changes could reflect inadequacies of modelling or be a consequence of the dynamics of facial growth; as bones are displaced and teeth erupt, the face may become suboptimally adapted to bear habitual loads, with subsequent remodeling adapting the form to these loads by adulthood.

This work will be extended to investigate these questions further and to compare the ontogeny of biting resistance among modern humans and Neanderthals. It will be of interest to investigate the extent to which similar findings arise in the fossils and to combine strain maps arising from different biting loads in both taxa in order to relate these to the known differences in their facial growth remodeling maps.

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Areni 1 and 2: two new Lower Paleolithic cave sites with core and flake lithic assemblages and faunal remains in Armenia

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Following the discovery of the *H. erectus* fossils and stone tools dating to 1.85–1.78 Ma at the site of Dmanisi in Georgia [1], recent field research in neighboring Armenia has focused on documenting Lower Paleolithic (LP) sites that may provide insight into the behavior of the first hominins to occupy Eurasia. The few LP sites under study in Armenia are all in open-air contexts [2]. Here, we introduce two newly discovered LP sites in karstic cave settings. Areni 1, situated on the left bank of the Arpa River, is globally famous for its Chalcolithic deposits, and their excellent preservation of organic remains that include the world's oldest leather shoe and the earliest evidence of wine production. Between 2007-2014, test trenches were excavated into the platform in front of the cave entrance. 210 LP artifacts associated with heavily mineralized bones were recovered from what appear to be mildly reworked Pleistocene sediments. Resembling those recovered at Dmanisi, the lithic artifacts are categorized as a simple core and flake, or Oldowan assemblage, with high frequencies of choppers or core-tools, flakes, and hammerstones. The assemblage also includes a few technological refits and high frequencies of flakes < 2 cm in maximum dimensions, suggesting low intensity reworking. The toolstones utilized at the site reflect the bedrock geology of the Arpa River catchment, and include a variety of sedimentary, metamorphic, and volcanic rocks. No bifaces (handaxes) or Levallois artifacts have been recovered from excavated deposits. Directly opposite Areni 1, on the other site of the Arpa River, another sequence has been exposed at Areni 2 cave, revealing Medieval, Bronze Age, Chalcolithic, and Neolithic artifacts overlying intact Pleistocene sediments that yielded a core and flake lithic assemblage and fossilized bones. The lithics recovered at this site techno-typologically mirror those recovered at Areni 1 [3], and again no handaxes or Levallois artifacts were recovered. We have initiated a long-term excavation project at the Areni 1 and 2 caves, aimed at documenting and dating the LP archaeology, and investigating site formation processes through detailed sedimentological, geoarchaeological, and chronometric analyses. The project also includes regional geomorphological study, and assessment of paleoenvironmental conditions through the analysis of well-preserved speleothems in deep karstic caves in the area. The Areni 1 and 2 cave sites will almost certainly yield abundant evidence of subsistence and land use behaviors of the earliest hominin occupants of the Armenian highlands. Such evidence is necessary to complement the finds from Dmanisi and other open-air sites in the region and bring into clearer focus landscape-scale adaptive behaviors. Occupation of enclosed sites, as at Areni 1 and 2, is an adaptation that has rarely been observed among the evidence for the earliest dispersals of hominin populations outside of Africa.

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Pleistocene differentiation in a successful generalist primate: evidence from modern cranial morphology in longtailed macaques

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The longtailed macaque (*Macaca fascicularis*) originated in the late Pliocene. It is presently widespread in Southeast Asia and seemingly very ecologically flexible. It diverged into various subspecies during the Pleistocene as it dispersed across the landmass known as Sundaland (which today is represented by the Malaysian peninsula along with the islands of Sumatra, Java, Borneo and surrounding smaller islands) and into the Philippines. This region is complex and fascinating, with its history shaped by the subsidence of the Sunda Shelf, and sea level fluctuations that separated the region into islands during interglacial periods and promoted the expansion of savannahs during glacials. Sundaland has evidence of hominin presence from the mid–to-late Early Pleistocene, but primate, including human, evolution in the region is understudied compared to the African record. The fossil record of *M. fascicularis* is poor, so in this contribution we use 3D geometric morphometric data based on 71 anatomical landmarks placed on ∼500 modern longtailed macaque crania to examine the patterns of divergence among *M. fascicularis* in the context of the palaeogeographic and palaeoecological history of Sundaland and adjacent islands. Molecular studies have identified two main mtDNA clades of *M. fascicularis*: a predominantly mainland clade that also includes northern Sumatra, and an insular clade (including southern Sumatra). Using principal component analysis, these clades are partly evident morphologically in form as well as shape space. Cranial specimens from the Philippines, classified as *M. f. philippinensis*, form a distinct cluster in morphospace. It seems likely that geographic separation and isolation caused these divergences, but the extent to which sea level fluctuations alone caused differentiation in *M. fascicularis* is still not clear as other island groups are not so clearly separated. The split between Sumatran and Bornean populations suggests that environmental variation also underlies phenotypic differentiation among longtailed macaques.

This region saw the evolution of at least two endemic island species of hominin, as well as the last appearance of mainland hominin taxa such as *Homo erectus*. Our findings provide a significant primate analogue for examining the importance of biogeographical and evolutionary impacts of glacial/interglacial cycles on these species. In particular, they shed light on the interacting effects of savannah environments, isolation, and reduction of island sizes brought about by the subsidence of the Sunda Shelf on a widespread and ecological flexible primate.

Genetic continuity between ancient and recent populations in Central Asia

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Southern Central Asia has been a crossroad for the movements of populations, cultures and goods between Europe, South Asia, East Asia and Middle East since prehistory. It has been under the influence from the North with the Steppe cultures and from the South with the Iranian culture for millenia. During the last 2000 years, populations speaking Turco-Mongol languages migrating from the eastern Asian populations partially replaced Indo-Iranian speakers. In precedent studies focusing on modern populations, it has been showed that there is a strong genetic difference between the modern Indo-Iranian population, and the Turco-Mongol speakers, with various amounts of admixture [1]. However, little is known about the origin of Indo-Iranian populations before 2000 years BP. Based on archaeological data, it has been suggested that Iron Age populations in Southern Central Asia were both related to Central Asia steppe populations (such as Andronovo) and Iranian population [2]. Despite its rich and complex history, Central Asia lacks genetic studies involving genomes from well-characterized and defined modern populations and ancient DNA to unravel the peopling of this region.

We confront a dataset of modern Indo-Iranian populations and Turko-Mongol speakers obtained in our lab, to the growing number of ancient genomes published from Eurasia. Ancient DNA analyses led on Eurasian samples have shown that migrations from the steppes vastly contributed to the European genetic diversity [3]. More recent works with ancient DNA has shown that Steppes groups have also migrated south to India and east to Mongolia, suggesting a role in the diffusion of Indo-european langages [4].

We first focused on Indo-Iranian speaking populations history. Using PCA, F3 stats and D-statistics, we first estimated the genetic continuity between the ancient individuals from Central Asia and the modern populations. Then we modeled Indo-Iranian speaking group ancestry with qpAdm and qpGraph as a 2- or 3-ways admixture. We find that modern Central Asia population speaking Indo-Iranian show a strong genetic continuity with Iron Age samples from Turkmenistan and Tajikistan and can be modelled as a very unbalanced 2-ways admixture of 93% Iron Age individual from Turkmenistan and 7% historical East Asian samples. When exploring Iron Age samples from Central Asia, we show that they are the result of the admixture between local bronze age population from BMAC culture, genetically strongly affiliated to Iranian Neolithic ancestry, and steppe populations. But contrary to what has been suggested by the archaeological record, it appears that the steppe populations that migrated and admixed with BMAC population is genetically closer to the western steppes (eg. Srubnaya) than to the Central Steppes (eg. Andronovo). We also do not see new Iranian genetic pulse at the end of the Bronze Age in the Iron Age samples, despite a strong cultural influence from there.

Finally, our results suggest that the history of Central Asia and its peopling is possibly more complex, as we can't exclude 3-ways admixture models between Iron Age central Asia samples, east Asian samples and European Scythian samples, than the common hypothesis of a double influence from its north and its south and suggest west to east population migrations.

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Is the Quina Mousterian from Chez Pinaud (Jonzac) really the oldest Quina in South West France? Bayesian analysis of OSL data

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Quina Mousterian is quite special in the variability of Neanderthal lithic industries. In addition, the Quina layers from Chez-Pinaud Jonzac, like most sequences in SW France, are extremely rich in reindeer remains, documenting particular subsistence strategies among the Quina makers. The overwhelming dominance of reindeer, which markedly differs from faunal spectra found in in association with other technologies in similar chronological and geographical contexts, also suggests a remarkable co-evolution of human behaviours and climate. It has long been suggested that Quina Mousterian could be attributed to Marine Isotope Stage 4, whereas more recent studies have tended to point to Heinrich event 6 (60 ka: see *e.g.* [1, 2]). In this context, the site of Chez-Pinaud (Jonzac) is the site where the oldest ages have yet been produced for Quina Mousterian: TL ages, despite rather large uncertainties, are consistent with MIS 4 (and even MIS 5) occupations [3]. While a wider project (ERC Starting grant 'Quina World' awarded to GG) will enlarge the scope to focus on Quina Mousterian across Europe in 2021-2025, here we present the results of single grain OSL dating of the full sequence of Chez-Pinaud (Jonzac).

12 sediment samples were taken at night under controlled lighting conditions. Sand-sized quartz grains were extracted following standard procedures for single grain OSL measurements. *In situ* dosimetry was performed using Al2O3:C dosimeters; beta dose rates were calculated from K, U and Th concentrations determined by high resolution gamma spectrometry. At the time of writing, all measurements are not yet finished and subsequent analyses are only partial, but: (i) the OSL signal is dominated by the fast component (and thus suitable for dating purposes) (ii) the intensity of the OSL response to fixed doses (25 Gy) is larger large (25 % of the grains give a detectable signal); (iii) equivalent doses are in the 50-100 Gy range and early saturation of OSL with dose only appears to be a marginal issue. In other words, the site of Chez-Pinaud (Jonzac) appears to be favourable to OSL dating.

To obtain a set of accurate ages, we apply a set of Bayesian models [4] to single-grain OSL measurements. While similar models have long been developed for radiocarbon dating, until recently no model was available to handle the specificities of OSL dating. Here a numerical chronology is obtained from a combination of OSL measurements and stratigraphic constraints, thus fully exploiting our knowledge of the site and improving uncertainties. Finally, we discuss the chronology of Chez-Pinaud (Jonzac) in the light of ages obtained for other Quina Mousterian layers in South West France.

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Australopithecus afarensis endocasts suggest protracted brain growth

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We undertake a comprehensive re-evaluation of brain growth and organization in *Australopithecus afarensis* by combining data on endocranial imprints [1] and virtual dental histology [2]. We scanned the *A. afarensis* infant from Dikika in Ethiopia (DIK-1-1) at the European Synchrotron Radiation Facility in Grenoble, France. Seven other well-preserved fossil crania from the Ethiopian Hadar site (A.L. 333-105, A.L. 162-28, A.L. 288-1, A.L. 333-45, A.L. 417-1, A.L. 444-2, A.L. 822-1) were scanned using conventional high-resolution computed tomography. We recently compared these *A. afarensis* fossils with modern humans and chimpanzees [1]. The evidence from virtual dental histology shows that the dental development of the Dikika infant was broadly comparable to that of *Pan troglodytes* and therefore faster than in modern humans. However, given that endocranial volume (EV) estimations suggest that the brains of *Australopithecus afarensis* adults were roughly 20% larger than those of chimpanzees, the Dikika child's small EV suggests a prolonged period of brain development relative to chimpanzees [1,3,4]. Here, we broaden our previous comparative framework [1] by adding cross-sectional endocranial growth data from gorillas and orangutans (total N=2062).

In addition to absolute endocranial growth curves, we also computed a relative endocranial volume (rEV) for all extant and fossil subadults as the ratio between EV and the adult mean EV of this species. While there is some overlap between the rEV values of great apes and humans, the average trajectories reveal species differences in the pattern of brain growth. We document considerable diversity in brain growth patterns among extant great apes. Our broad comparative ontogenetic dataset suggests that reducing an evolving system to a dichotomy of "human-like" vs. "chimpanzee-like" obscures the complexity of actual evolutionary trajectories within the hominin lineage. It is likely that patterns of brain development varied among hominins and did not follow a linear evolutionary trajectory towards the modern human condition.

Prolonged brain growth and maturation have often been viewed as a consequence of evolutionary brain size increase in the genus *Homo*, i.e. a shift in life history required to evolve large adult brains despite obstetric constraints related to upright walking. In contrast to this view, our data suggest that prolonged brain growth is not a mere by-product of evolutionary brain size increase. Growth and maturation rates are associated with infant care strategies in primates, suggesting that the prolonged period of brain growth in *Australopithecus afarensis* may have been associated with a long dependence on caregivers. Initially, slow brain growth may have evolved as a way to distribute the energy needs of dependent offspring over many years in environments where food is not abundant. Protracted brain growth in *Australopithecus afarensis* provided a basis for the later development of the brain and social behaviour in hominins, and was probably crucial for the development of an extended period of childhood learning.

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Are subspecies of African apes morphologically distinct? Evidence from the maxilla

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Differences in morphology among extant African apes are frequently used in attempts to recognise species in the human fossil record. A good understanding of the degree and structure of intraspecific variation, including aspects such as sexual dimorphism and geographical diversity, are key in this context. First recognised as geographical clusters, subspecies of African apes are increasingly well defined on genetic grounds. However, whether they show consistent skeletal differences, as a substantial component of intraspecific variation, is less clear.

Here we explore differences at the subspecies level in African apes, focusing on maxillary morphology as it is central in diagnoses of hominin taxa such as *Paranthropus*, *Kenyanthropus platyops*, *Australopithecus deyiremeda* and *Homo rudolfensis*. The shape of the maxillae was captured using 68 three-dimensional landmarks in the commonly accepted subspecies *Pan troglodytes troglodytes* (n=33), *P. t. schweinfurthii* (n=33), *P. t. verus* (n=33), *Gorilla gorilla gorilla* (n=80), *G. g. diehli* (n=24), *Gorilla beringei beringei* (n=26), and *G. b. graueri* (n=80), sampling large geographical areas and both sexes. Principal component analyses show that maxillary morphology differs between all subspecies of each African ape species, although with a substantial degree of overlap. These results confirm that these subspecies are not only geographically and genetically defined, but can indeed be characterised using aspects of facial morphology. Moreover, they demonstrate that the maxilla can provide useful information when exploring taxonomic diversity among hominids at a genus, species and subspecies level. Given the morphological differences between subspecies identified here, these results highlight that in comparative studies any samples of *P. troglodytes*, *G. gorilla* and *G. beringei* should preferably include all subspecies to give a comprehensive representation of their intraspecific variation. Exploring the degree and pattern of morphological variation of the maxilla in and between African ape species will contribute to a better understanding of the hominin fossil record, in particular in relation to little known species such as *K. platyops*, *A. deyiremeda* and *H. rudolfensis*.

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Apidima 1 and the early dispersal of *Homo sapiens* out of Africa

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S.-E. Europe represents a major dispersal corridor and a principal European Mediterranean glacial refugium. Its geographic position would suggest an early, continuous and variable human fossil record, reflecting the complex demographic processes of repeated multidirectional dispersals, late survivals, and possible cultural and biological interactions among different human groups. Data from this region, therefore, are of crucial importance in testing hypotheses about the course of human evolution and adaptation, as well as migration to and from, the European continent. However, such data are scarce, as its human fossil and paleolithic records relatively poorly known. The fossil human crania from Apidima cave, Mani (Southern Greece), are among the most important specimens from S.-E. Europe, yet their affinities and chronology were until recently unknown due to taphonomic distortion and breakage, lack of associated context, and lack of detailed description and comparative analysis. Recently, we virtually reconstructed the two specimens using standard virtual anthropology approaches, conducted a comparative description and geometric morphometric analysis and dated the human remains and associated matrix using the U-series radiometric method [1]. Apidima 2 dates to >170 ka and conforms to a Neanderthal-like morphological pattern; however, Apidima 1 was dated to >210 ka and presents a mixture of modern human derived features and ancestral morphology. We concluded that an early *Homo sapiens* population, followed by a Neanderthal one, was present at the Apidima site in the Middle Pleistocene. Although early *H. sapiens* are known to have reached the Levant by ca. 185 ka [2], the European continent has until now been considered the exclusive realm of *H. neanderthalensis* until the arrival of modern humans associated with Initial Upper Paleolithic technocomplexes ca. 45 ka [3]. Apidima 1, therefore, emerges as a potentially crucial specimen evidencing an early, geographically far-reaching, dispersal of H. sapiens out of Africa. It preserves mostly the back of the cranium and is undistorted, allowing virtual reconstruction by mirror-imaging. It lacks Neanderthal-like rounded 'en bombe' profile in posterior view, as well as an occipital convexity, showing instead a rounded posterior profile in lateral view, a derived modern human trait. Its parietal walls are nearly parallel and the occipital plane low, both plesiomorphic conditions. Unlike many Middle Pleistocene specimens, it shows no angulation of the occipital bone or an occipital torus. Principal Components Analyses of the overall shape of the neurocranium and midsagittal profile place Apidima 1 with modern humans, to the exclusion of Neanderthals or Middle Pleistocene Europeans / Africans. Its overall shape is closest to modern human specimens and it is classified as *H. sapiens* with posterior probability > 0.9 in all analyses. Despite the lack of Neanderthal features and the results of its shape analysis, a small, faint depression above inion might be argued to reflect Neanderthal affinities for Apidima 1. The suprainiac fossa is considered as a derived Neanderthal trait, but similar depressions occur among modern humans and some African early *H. sapiens*. Measuring ca. 12 mm in length / 4.55 mm in height, the Apidima 1 depression lacks clear borders and is much smaller than Neanderthal fossae (mean length 38.3 mm, height 15.1 mm, see [1] and references therein). Furthermore, its internal morphology differs from the Neanderthal condition [4], instead showing a faint thinning of the outer bone table that does not affect the diploic layer. It is therefore most similar to those described for African Middle-Late Pleistocene specimens [5]. We therefore conclude that, on the basis of currently available evidence, Apidima 1 is best interpreted as an early *H. sapiens* individual.

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Evolution of Lithic Technological Systems: Exploring Trend, Tempo and Mode

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Evolution of Lithic Technological Systems: Exploring Trend, Tempo and Mode Our research explores the trend, tempo, and mode of the major transitions in lithic technology stretching from Mode 1-5. These changes were examined from a systemic context by integrating ideas involving systems of lithic technology, optimal foraging theory, and complex adaptive systems. The study centered on the evaluation of lithic edge production efficiency (EPE) observed in artifact samples selected from southern Levantine assemblages representing Modes 1-5. Artifacts from the sites of 'Ubeidiya (1), Gesher Benot Ya'aqov (2), Tor Faraj (3), Tor Aeid, Jebel Mishraq and Wadi Judayid were weighed and scanned, and their images uploaded into image-processing software for tracing their perimeters and acute edge lengths. To evaluate EPE, we calculated an Edge Production Index (EPI) for each of the artifacts and associated assemblages. EPI is the ratio of acute working edge to the weight of focal blanks (flakes and blades) and core tools (chopping tools and bifaces). The trend in EPI showed a progressive increment through time. Between Modes 1-5, the EPI increased a remarkable 2,300%. The EPI of Mode 2 remained virtually the same as Mode 1; the Mode 3 assemblage showed a 500% increase over Mode 2 EPI, and Modes 4 and 5 each showed an increment of about 200%. Flakes followed by blades were noted as the principal sources of the progressive rise in EPI. Analysis of tempo pointed to an accelerating rate of change over time with progressively shorter-term intervals separating systemic shifts in lithic production thought to be represented by intermittent autochthonous developments that were subsequently spread through cultural as well as demic diffusion. To better understand mode, i.e., what drove the cultural innovations, we analyzed these changes within the framework of micro and macroevolutionary processes with an approach that examined short-term ecological relationships as a means of understanding long-term evolutionary trajectories guided by selective forces over deep time. Since the greatest rate of change in lithic production systems, increased emphasis on laminar production and concomitant diminution of blanks, occurred in Levantine lithic assemblages from the Late Middle Paleolithic to the Late Epipaleolithic (Modes 3-5; MIS 4-1), this time frame was used as the basis for the model. Following the work of McShea (4), we applied the minimum and subclade-skewness tests to our dataset. Results were consistent with a selective (adaptive) evolutionary driver of change rather than a passive basis for the EPI trend. Since these changes occurred at broad temporal and spatial scales, they are most analogous to those at the macroevolutionary level. To study EPI changes attributable to microevolutionary factors, the relationships of lithic reduction systems were examined using a model based on Optimal Foraging Theory (OFT) conditioned by the distribution of fixed resources of knappable lithic material, essential fluid resources (water, food and fuel) and centrally placed camp sites across a landscape. A decline in the density and quality of fluid resources would have prompted the repositioning of centrally placed encampments, often increasing the distance/cost of procuring/portaging lithic material and, in turn, selecting for more efficient lithic reduction strategies as reflected in higher EPIs. Importantly, the synchronicity observed between the major Levantine lithic technological transitions and millennial scale drought episodes accompanying Heinrich events 5-1 (5) are consistent with our proposed correlation between amplified EPE in lithic assemblages and higher lithic transport costs resulting from a reduction in the density of fluid resources.

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Intensive re-use of stone tools as bipolar implements in the Initial Upper Paleolithic of Bacho Kiro Cave

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Bacho Kiro Cave is an important site in the pursuit of a better understanding the arrival of *Homo sapiens* in Europe. Located in the northern slope of the Balkan Mountain range in Bulgaria, the site has a rich chrono-stratigraphic sequence spanning from the Middle to the Upper Paleolithic and is known for its so-called Bachokirian from Layer 11 excavated in the 70s [1]. New investigations at the site have produced large lithic and bone assemblages from this layer (now Layer I and classified as Initial Upper Paleolithic) along with *Homo sapiens* remains and a new chronology of the UP occupations [2,3]. The IUP technology comprises a fusion of MP and UP features, including: Levallois techno-typological features and hard hammer percussion together with opportunistic bladelet production, blade tools and bipolar technology [4]. The latter is interesting because bipolar technology is common in LSA occupations in Africa and in the European and Levantine UP but rare in MP assemblages [5].

This poster presents a preliminary techno-functional analysis [5] of the IUP bipolar technology assemblage and contributing to the understanding of the variability resulting from the reuse of lithics on anvil. The results show patterns likely linked to raw material availability and tool function. Bipolar cores represent 53% of cores at the site. Bipolar knapping was used as an alternative to free-hand knapping for small raw material volume reduction. Small cobbles were split on anvil to be used for other activities. Flakes, blades, cores and fragments were used as wedges for working hard organic materials (e.g. bone and antler), turning them into scaled pieces. Anvils seem to have been used as base support for bipolar knapping and wedging due to constant presence of impact features. Furthermore, we can observe economization of raw material, likely linked to the distant raw material sources. This is evident in the degree of re-use of both formal stone tools, cores and blanks as both bipolar cores and wedges. Up to three stages of re-use have been identified in several tools. These functional stages seem to consistently follow the same order: a former tool/core is first placed on anvil to be re-used as a core for blank extraction, afterwards it is horizontally rotated to maximize the area of which blanks can be extracted and lastly if the tool still preserves sturdiness and a pointed edge, it is re-used as a wedge. In these artifacts, the final function as a wedge can be seen in 79% of cases, which is to be expected due to the destructive nature of this activity. In fact, 53% of scaled pieces used as wedges were used until depletion, as they displayed large transversal or longitudinal fractures.

Our results show that *Homo sapiens* at the site were strategically employing bipolar methods. This is shown not only by the plethora of activities carried out at the site but also in the understanding of how these methods were used as an adaptive strategy for mediating environmental pressure by enhancing resource extraction. This is evident, for instance, in the lithic reduction strategies, by continuing to extract blanks from cores too small for free-hand knapping. In addition, the continuous re-use of scaled pieces as wedges for working hard organic materials, allowed for controlled carcass processing in the form of bone marrow extraction, rib splitting, etc. and bone shaping/modification for the production of formal bone tools. While often considered expedient and of low cognitive value, the BK IUP bipolar assemblage shows how the groups understood how the use of bipolar methods could enhance resource extraction, therefore enhancing their environmental adaptation. This work provides insights into potential differences in how Neanderthals and early *Homo sapiens* evaluated and achieved efficiency in the use of stone resources for mediating environmental pressure in their respective adaptive strategies.

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Homo sapiens dispersals into Europe in light of the Bacho Kiro Cave results

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To date, the detailed process and exact timing of the replacement and partial absorption of local Neandertals by *Homo sapiens* populations of African origins remains largely unknown in most parts of Eurasia. These uncertainties also concern Europe, although this region represents an area where the late Middle to early Upper Paleolithic time period has been extensively studied. Many of these issues center on the interpretation of so-called "transitional industries" of which the relationship with local Middle Paleolithic assemblages and the biological nature of the makers are debated. Apart from these western Eurasian technocomplexes, a group of assemblages rooting in south-east Asia and spreading from central Europe to Mongolia before 45,000 cal BP has been described as representing an "Initial Upper Paleolithic" (IUP) distinct from the later early forms of the Upper Paleolithic of western Europe [1].

The geographical and chronological development of the IUP was proposed by some to represent a marker of the first dispersal of H. sapiens in the mid-latitudes of Eurasia [2]. However, although fragmentary hominin remains were yielded by IUP layers at Ksar Akil (Lebanon) and Üçağızlı Cave (Turkey), this long remained difficult to establish. New excavations at the site of Bacho Kiro Cave demonstrated the direct association of a rich IUP assemblage to human remains both anatomically and genetically identified as *H. sapiens* thus supporting the notion that the IUP/*H. sapiens* association is valid, at least in this part of Eurasia [3]. The direct dating of the Bacho Kiro IUP hominins places them between 44,000 and 46,000 cal BP. However, IUP likely starts ca. 47,000 cal BP at the site [4]. Other possible IUP hominins include the Ust'-Ishim (western Siberia) and the Peștera cu Oase (Romania) specimens, but both sites lack archaeological context and the published age of the Romanian fossils between 42,000–37,000 cal. BP are likely underestimates. In contrast to later Upper paleolithic European hominins, the available paleogenetic data suggests that the IUP early wave of peopling is unrelated to present-day European populations.

The Bacho Kiro Cave evidence highlights the long chronological overlap of *Homo sapiens* and Neandertals at the scale of Europe. The replacement of one group by another was a complex process, possibly lasting 7,000 or 8,000 years. Although there is no evidence of long-lasting coexistence in a given region, the geographical scale of the sub-continent makes likely, not to say inevitable, biological and cultural interactions between the two groups over millennia. These interactions are not only documented by the recent Neandertal DNA introgression in the genome of Peștera cu Oase but also by the striking similarities between the pendants produced by the IUP dwellers of the Bach Kiro Cave and those found in the Châtelperronian layers at Grotte du Renne (France).

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Stone Artifacts of Aghitu-3 Cave and a Spotlight on the Earliest Modern Human Behaviors in Armenia

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This paper presents the results of a study of the early Upper Paleolithic stone artifacts from Aghitu-3 Cave, which represent the earliest evidence for modern human behavior in Armenia. The study forms part of a dissertation project funded by the Gerda Henkel Foundation and focuses on the oldest archaeological horizons – AH VII, AH VI.1 and AH VI.0. These three layers date between 39,000 and 32,000 cal BP.

To understand people's lives and activities at Aghitu-3, we studied the materials they left behind, mainly stone artifacts. Obsidian dominates the assemblage with 77%, followed by 22% chert. The few remaining artifacts (about 1%) consist mainly of dacite and basalt. The people who inhabited Aghitu-3 preferred rocks of a specific shape. They selected blocks without cortex where the intersection of two surfaces created an angle of about 70 degrees. They created a striking surface with one or two quick blows on the face that would become the reduction surface, with a preference for rectangular-shaped reduction surfaces and an orthogonal orientation for the extraction of blanks. We note that the cores are large when compared to the youngest layer of the site (AH III, 29-24,000 cal BP). People shaped the cores quickly to achieve a desired form, but often experienced technical problems, which led the knapper to discard the cores before they were fully used. Once they set a core up, people focused almost exclusively on the extraction of laminar blanks, including blades (width ≥10 mm) and bladelets (width <10 mm). They relied most heavily on the production of bladelets, which represent up to 85% of the assemblage. While backed bladelets are completely lacking in layer AH VII, they appear infrequently in layers AH VI.1 and AH VI.0. We observe a reliance on light retouch in shaping the blades and bladelets of these layers, ranging from fine to semi-abrupt. Laterally retouched bladelets are medially preserved and mostly straight (not curved). Based on an experimental study, we suggest that people used them as components of composite tools for cutting and slicing. Burins in Aghitu-3 Cave were an important tool, and a few removal spalls are present. In some cases, these spalls were retouched and reused. In rare cases, we see that burins were used like cores to extract several spalls, and in other cases, we infer that burins were used as tools. Other types of tools exist in the lower layers, such as drills, denticulates and splintered pieces.

These three layers represent the oldest phases of settlement known from the Upper Paleolithic of Armenia and provide insight into the behavior of the first groups of people who settled there. These stone artifacts were made by groups of people who preferred laminar debitage for producing their tools such as composite knives, burins, scrapers and drills, which they used for cutting, piercing, slicing and working on wood and bone. We interpret the diversity of activities in the cave to demonstrate repeated, short-term settlement, for example, use as a seasonal hunting camp. This type of technology continued to dominate during subsequent phases of settlement at the cave until 24,000 cal BP. Together these finds provide the earliest evidence for modern human behavior in Armenia.

Gerda Henkel Stiftung, The Role of Culture in Early Expansions of Humans (ROCEEH), Institute of Archaeology and Ethnography in Armenia

A novel and validated avenue for behavioral reconstructions in the fossil record: a critical presentation of new interdisciplinary evidence

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A paramount objective of human evolutionary sciences is to reconstruct the habitual physical activities of past human populations and fossil hominins, providing crucial insights into their lifestyle, subsistence strategies, and the factors driving bio-cultural evolution. The surface areas of the bones where muscles attach, entheses, have been extensively used as skeletal indicators of activity-induced biomechanical stress [1]. However, several recent studies have consistently questioned the reliability of these structures as occupational stress indicators, mainly relying on the low measuring precision of traditional analytical techniques (visual scoring systems) as well as the absence of supportive experimental evidence for an interaction among physical activity, muscle architecture, and entheseal form [1]. Here, we aim to overview and critically discuss a series of our recent interdisciplinary studies, which put forth a novel and highly repeatable three-dimensional (3D) approach for reconstructing activity based on entheses. This new entheseal method is the first to be validated based on cross-institutional and blindly conducted laboratory studies [2,3]; as well as using recent human skeletons with uniquely detailed and life-long occupational documentation [4].

In contrast to previous approaches relying on the direct comparison of single entheseal structures across individuals of distinct characteristics [1], our multivariate 3D approach focuses on identifying correlations among different entheses that correspond to frequent muscle synergy groups [2,4,5]. Furthermore, we have also supported the functional significance of entheseal morphology through histological microscopic research on human body donor cadavers as well as original 3D geometric morphometric analyses. The recent application of this new method on a diverse sample of Neanderthal hand skeletons provided the first anatomical evidence to reflect the latest archaeological and experimental indications for a habitually precise manipulatory behavior in that species [5]. Overall, we believe that the findings of this novel approach, which comprises one of the few anthropological methods to be experimentally validated on an interdisciplinary basis, highlight its great potential in reconstructing crucial aspects of human bio-cultural evolution.

We are extremely grateful to all our close collaborators in the interdisciplinary projects discussed in this presentation, including Gerhard Hotz, Vangelis Tourloukis Ian Wallace, Nathan Jeffery, and Konstantinos Moraitis. We would also like to thank all institutions and researchers who kindly provided us with access to fossil materials. Last but not least, we are grateful to the volunteers of the 'Citizen Science Project Basel Spitalfriedhof'(University of Basel) for their important work in developing the unique lifelong occupational documentation of our modern human reference samples.

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Thinning, resharpening, and tranchet flake removals: how torque creation and force variation along the cutting edges of handaxes may have influenced Acheulean tool production practices

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One of the defining characteristics of Acheulean handaxes is the presence of a substantial length of sharp cutting edge, often covering the majority or entirety of their plan-form outline. Often, these tools also display tip-focused edge modification in the form of increased thinning and resharpening, and *tranchet* flake removals. Recently, factors affecting the efficiency and effectiveness of handaxes for cutting have come under increased scrutiny. Most studies investigate how shape, size, symmetry and other metrics influence cutting performance characteristics. This includes investigations of edge morphology. To date, it is unknown how cutting performance may vary within an individual handaxe dependent on which aspect of its edge is used.

Here, we experimentally investigate how loading capabilities (applied forces) vary along the edges of handaxes, from tip to base. We identify significant differences dependent on the edge-point loaded, with greater forces recorded at the tip of tools relative to more proximally located edges. Notably, at ~20% of a handaxe's length away from the tip, loading levels were reduced by around 24%. Hominins concerned with maximising cutting stress potential during tool use should, therefore, have preferentially used the tip portion of handaxes when possible. During broader, sweeping cutting motions that use substantial lengths of cutting edge, our data suggest different portions of the edge create variable cutting-stress levels. We argue that such differences likely derive from increases and decreases in torque creation, and the interaction between cutting forces and ergonomic relationships at the hand-tool interface. Indeed, dependent on the edge-point loaded, torque (force attempting to rotate the tool in the hand) acting on handaxes varies substantially. We suggest that these relationships may have influenced handaxe design during the Acheulean period and promoted tip focused edge modifications such as *tranchet* flake removals, thinning, and increased resharpening.

Early and Middle Pleistocene large carnivore guilds of Europe and their role in the evolution of hominin subsistence strategies: an ecomorphological and behavioral approach

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Archaic humans (early *Homo*) and carnivores inhabited the Early and Middle Pleistocene landscapes of Europe, and shared ecosystems for more than 1 million years. Indeed, many archaeo-palaeontological sites evidence the co-existence of humans and carnivores, and demonstrate a certain degree of human-carnivore competition for acquisition and exploitation of animal (meat/bone) resources. We investigate here the role of large carnivores in the evolution of hominin subsistence strategies during the Early and Middle Pleistocene of Europe, focusing on important renewals in the carnivore guilds, and their significance in terms of carrion availability for scavenging and human-carnivore competition for access to food resources. Based on a previous ecomorphological approach of carnivore guild analysis [1], a modified version was recently employed [2] and is presented herein, combining four ecomorphological/behavioral parameters of large carnivores (body mass-BM, diet, hunting strategy, sociality) that practice hunting and/or scavenging on large prey. 3D guild structure diagrams were constructed and analyzed aiming to: 1) examine the community structure and dynamics of the predatory guilds, 2) infer the possible role of carnivores in the changes of early *Homo* subsistence strategies (passive/active scavenging and hunting), and 3) assess the role of hominins within the guilds.

The late Villafranchian–Epivillafranchian (Early Pleistocene) carnivore guild was dominated by large-sized, hypercarnivorous and ambush-hunting felids (e.g., the saber-toothed cats *Megantereon* and *Homotherium*), and by the large-sized, bone-cracking and scavenging hyaenid *Pachycrocuta*. The latter in particular was the most direct competitor of *Homo* for scavenging food resources (leftovers) left behind mainly by the saber-toothed cats [3]. As a member of the predatory guild (evident from the presence of cut and percussion marks on mammal bones), *Homo* would occupy the ecological space that was "available" for a predator with a 30–100 kg BM and a (mostly?) scavenging behavior, perhaps with a hypocarnivorous/carnivorous diet according to ecological circumstances and geographic setting. The disappearance of most of the Early Pleistocene carnivore components (including *Pachycrocuta* and *Megantereon*) towards the end of this period, and their replacement by the Galerian (Middle Pleistocene) to modern hyenas and felids, resulted in the change of the structure and dynamics of the guild. Most notably, this reorganization included the decrease of carrion providers (hunters), and the higher representation of species with scavenging, bone-cracking and pack-hunting behavior. In this Middle Pleistocene guild, *Homo* would occupy the niche that was previously held by *Megantereon*, in the group of predators with 30–100 kg BM. Similar to *Megantereon*, humans could have a carnivorous to hypercarnivorous diet, but unlike the solitary and "ambush-and-slash" felid, the biological, technological, cultural and social developments would have allowed humans to employ a modified hunting strategy: the cooperative "ambush-and-spear" strategy (in accordance with the use of hunting spears during this period). The incorporation of such hunting behavior made humans fairly independent of erratic food sources from scavenging carnivore kills and allowed the provisioning of animal resources on a more regular basis. Moreover, even though the carnivore diversity slightly increased during this period, carnivore representation in the archaeo-palaeontological localities is rather low in both species and specimens number. This is possibly an anthropogenic effect on the ecosystem due to: 1) the firmer establishment of the hominin niche, including anti-predator strategies and expulsion of large carnivores from the region of human influence; and 2) the reduction of food quantity through human confrontational scavenging or decrease in prey availability through human hunting (see also [4] and [5]).

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Pleistocene prey and predators: calcium isotopes as a tool for trophic web reconstruction, applied to Australian megafauna

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A key aspect in understanding the dispersal of hominins, (including Anatomically Modern Humans) out of Africa is to explore the niche(s) that hominins were able to occupy in the local ecological communities. Australia provides the opportunity to explore the trophic web dynamics of Pleistocene fauna just before human arrival, as this isolated continent shows no indications for hominin occupation prior to Anatomically Modern Humans and their sudden presence would not have been part of a larger faunal turnover. During the late Quaternary, large vertebrates (megafauna) roamed Sahul: mega marsupials, large, carnivorous birds and giant, venomous lizards paint the picture of a competitive environment. While most research focuses on the interaction of Late Pleistocene humans with megafauna as a group, only few studies regard the co-existence and competition between the megafauna taxa.

The structure and dynamics of trophic webs (e.g. interspecific interaction, prey-predator relations and niche competition) has received little attention due to the previous lack of suitable proxies. Here we apply novel methods from isotope geochemistry to dental enamel of mega marsupials from several sites in NSW, Australia, in order to reconstruct the dietary niches that these species occupied throughout the Pleistocene. Calcium isotope analysis ($\delta 44/42Ca$) is used to determine the trophic level of species, thus assessing prey-predator relations prior to human arrival. As the main component of bioapatite, Ca is very unlikely to be affected by diagenesis, particularly as it is applicable to dental enamel in which the crystalized structure leaves little room for infiltration. Therefore, $\delta 44/42Ca$ analysis proves to be applicable to large timescales and harsh preservation environments. The potential of Ca isotope analysis as a tool for trophic web reconstruction is strengthened when combined with other isotopic systems. Here we complement it with strontium (Sr) isotope analysis ($87Sr/86Sr$) in order to track habitat ranges. Together, these methods identify different feeding strategies within a community of megafaunal species, shedding light on resource competition and niche partitioning.

Overall, understanding the paleobiology and paleoecology of megafauna in the absence of humans allows for a comparison to environments in which humans may have played a role, e.g. the disappearance of megafauna in Australia and perhaps worldwide. Moreover, the new technique of Ca isotope analysis has the potential to test important hypotheses in the field of human evolution.

Ergonomic strategies and Hierarchical Task Analysis (HTA) of human hand during stone tool production

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One of the reasons for the success of the genus homo is the increasing dexterity of the hand and the effectiveness of Palaeolithic stone tools. However, the link between the anatomical evolution of the human hands and the cumulative level of sophistication of Palaeolithic stone tools is still under investigation. Biomechanical analyses of the human hands are receiving a growing deal of attention over the years. However, the manual abilities of the human hands during the production of Palaeolithic stone tools remain poorly known from an ergonomic point of view (i.e. the level of efficiency and body effort required for the manufacturing of stone tools).

Therefore, this study aims to quantify the functional and behavioural strategies used by five skilled flintknappers during the production of specific Palaeolithic debitage methods, such as Lomekwian, Oldowan, and Acheulean reduction sequences. The experiments, conducted and recorded remotely and online (due to Covid-19 restrictions), focused on (i) the hand grips and movements, (ii) the hierarchical and cognitive repetition of tasks (i.e. HTA analysis) executed by each experienced flintknapper during the manufacture of specific Palaeolithic debitage methods, and (iii) the degree of body effort required to finalise each task (i.e. REBA and RULA analyses). Initial results show that Lomekwian reduction sequences require the lowest number of functional and cognitive tasks with lowest ergonomics stress scores, whereas Acheuleuan reduction sequences recorded the highest number of tasks, suggesting a sharp change in cognitive abilities and manipulative skills associated with the increasing sophistication of Palaeolithic debitage methods.

The preliminary results of this study will determine the different functional and cognitive tasks involved in the manufacture of Palaeolithic stone tools and the required manual ergonomics stress of the human hand. This will support the recognition of patterns of performance and effort of the upper limbs involved in the evolutive process of flintknapping. Ergonomics analyses are here considered an essential preliminary tool to identify biomechanical strategies of human hands in future kinematic analyses.

Keywords: Evolution of human hand, Ergonomics (HTA, REBA, RULA analyses), Stone tool evolution, Lomekwian, Oldowan, Acheulean tool making.

Neanderthals possibly persisting later than thought

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Despite the growing number of dated archaeological specimens of Neanderthals across Eurasia, the timing and cause of the species' extinction remain unclear because of the spatial heterogeneity of Neanderthal remains and widespread chronological incoherencies. Correcting for these spatial and taphonomic biases is critical to estimate the patterns of Neanderthal extirpation (i.e., regional extinction) and to test hypotheses regarding the processes underlying the chronology of Neanderthal extinction. Western Europe, and especially the Iberian Peninsula, is considered a refugia for the last-surviving Neanderthals but those regions are also of highest data quantity during the period of youngest estimated occurrences 28,000–41,000 years ago [1,2]. However, despite the relative abundance of Neanderthal remains, reconstructing the chronology of Neanderthal extirpation is still a challenge because the radiometric dates from which it is built are often unreliable or inconclusively linked to particular archaeological remains. Such uncertainties thus prevent testing hypotheses regarding the relative role of ecological or physical processes to local disappearance patterns and make the relative contribution of possible extinction drivers in this region is particularly polemic. To map a spatial and taphonomic bias-corrected extinction chronology, and to test the processes that could have been involved in the extirpation, we considered, evaluated and analysed most Neanderthal dates in western Europe. We selected data based on three criteria: *(i)* confirmed occurrence of Neanderthals, *(ii)* only reliable age estimates, and *(iii)* ages clearly associated with Neanderthal remains. To assess the reliability of age estimates, we built a protocol that considers the dating method and the quality of the sample dated. We then applied to these data a spatiotemporal model [3] that accounts explicitly for spatial and taphonomic biases of the dated archaeological remains and corrects for the Signor-Lipps effect (the last fossil does not represent the last presence) the most probable distribution of Neanderthals in western Europe prior to extinction. To test the potential role of climate change in shaping Neanderthal extirpation patterns, we statistically compared this estimated pattern of extirpation to regional variation in hindcasted climate conditions derived from the LOVECLIM Earth-system model. Surprisingly, our model predicts that Neanderthal probably survived until at least 25,000 years ago. Our results further highlight spatial disparities in the extirpation dates of Neanderthal and identify areas where this pattern most relates to environmental conditions.

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An updated review of the fracture mechanics of flaking and its implications for hominin behavior

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A fundamental understanding of the physical mechanics of flaking is necessary in the study of lithic technology and its implication for the behavior and cognition of past hominins. The flake formation process is controlled by the basic laws of fracture mechanics, which hold true regardless of changes in the external environment. It is thus essential for us to understand and explain variation in the lithic assemblages from a fracture mechanics perspective. This allows us to find out the actual variables at work during flaking and how they were exploited by the early hominins when producing the stone tools. Knowing exactly what to look for equips us with the knowledge needed to track and determine how knapping skills have changed through time, and whether the tool makers understood the effect of different knapping variables from the archaeological record. The field of fracture mechanics offers a rich literature on the basic principles of fracture initiation and propagation in brittle solids. Lithic experiments such as conducted by Speth, Cotterell and Kamminga also study conchoidal flaking from a fracture mechanics perspective. While these fracture mechanics-based studies offer a rather detailed explanation (often mathematically laden) of some important aspects of flaking [1-3], our ability to generalize these experimental results to the archaeological assemblages remains limited. In addition, few follow-up studies have been conducted to bridge the gap between the basic flaking mechanics and its practical application to the archaeological record since Speth, Cotterell, and Kamminga. In this study we will review evidence of brittle fracture (especially formation of the Hertzian cone) from the relevant literature. Our goals are to: 1) provide an up-to-date analysis of how the flaking process is governed by the laws of fracture mechanics, 2) investigate the possible implications of flaking mechanics for hominin behavior and cognition. Here, we introduce a mechanical setup, which controls flaking variables that are arguably most relevant to the fracture mechanics mechanisms. These variables have not been systematically investigated in the previous lithic experimental studies. Specifically, we are interested in studying the effect of striking force and angle on flake mass and the length of bulb of percussion. Together with results from the published controlled lithic experiments [4, 5], we demonstrate the applicability of laws of fracture mechanics in understanding flake formation. Our results are yielding new insights into how changes in the early hominins' knapping strategies are reflected in the lithic record.

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Quantification of hypoplasia depth in Neandertal and Upper Palaeolithic modern human molars

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Linear enamel hypoplasia (LEH) appears as localized reductions in enamel thickness in the form of accentuated horizontal grooves on the tooth surface. LEH defects are the product of growth disruptions during dental development, reflecting metabolic stressors in early life. Previous research has linked LEH depth to the severity and duration of growth disruptions events [1,3], implying that defect depth might be used as a proxy for stress severity. However, defect depth is also affected by the rate of enamel growth, with faster-growing teeth generally having shallower defects [1,2]. While there are clear differences in growth rates in Neandertal and Upper Paleolithic modern human (UPMH) anterior teeth, debate still surrounds the extent of such differences in their molars. Further, little is known about the early life stress experienced by these groups. The timing of molar development corresponds to critical life history events [4], yet molars are rarely analysed for LEH.

Here we applied a standardised confocal profilometry method [1] to establish for the first time the depth of both normal perikymata (N=1098) and LEH defects (N=195) in a total sample of 97 Neandertals and UPMH upper and lower molars (M1-M3). The results of this study show mostly nonsignificant differences in perikymata and defect depths in the molars of the two taxa with two exceptions: perikymata on average were significantly deeper in the LM1 of Neandertals compared to UPMH, and defects were significantly deeper in the LM3 of UPMH compared to Neandertals. Yet, the latter finding became nonsignificant when defect depth was scaled to perikymata depth (in order to control for potential variation in growth patterns between the two taxa). The results of this study suggest that both groups experienced stressors of similar magnitude in later childhood years, potentially contradicting suggestions that Neandertals were generally more "stressed" than UPMH [4]. The lack of significant difference in perikymata depth between Neandertals and UPMH molars, however, fit in with previous research suggesting similar developmental patterns in the posterior dentition of these two groups [5]. Our findings and their implications will be further discussed in the light of those available for the anterior teeth. Overall, our study is the first to assess quantitative evidence for Neandertal and UPMH molars' perikymata and hypoplasia depths using a very large sample. We found significant overlap between the two groups, suggesting broad similarities in their rates of dental development and stressful life events.

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Covariation between mineralized area and shape of the rib cross section in *Homo sapiens* and *Pan troglodytes*: implications for the interpretation of *Australopithecus africanus* Sts-14 ribcage

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Like many other anatomical structures, the ribcage has changed its morphology and configuration throughout primate evolutionary history. Unfortunately, ribs usually appear broken in the fossil record, which challenges the interpretation of their morphology. In this context, it has been observed that the mineralized area of the rib cross section at the midshaft (Min. Ar. Mid.) could be informative not only about the functional differences in the upper and lower thorax, but also could explain potential interspecific biomechanical changes during evolution [1-3]. As these changes may also be associated with the shape of the rib cross section at the midshaft (Sh. Mid.) [2,3], studying the covariation between both parameters could be interesting in order to understand thoracic biomechanical evolution in hominins from a fragmentary fossil record [2].

This issue was assessed through the analysis of the internal rib microstructure via micro-CT of 5 typical ribs of the *Australopithecus africanus* Sts-14 from the Ditsong National Museum of Natural History (Pretoria, South Africa) and the complete set of ribs of ten modern humans (*Homo sapiens*) (120 ribs) from the Universidad Autónoma de Madrid (Spain) and ten chimpanzees (*Pan troglodytes*) (130 ribs) from the American Museum of Natural History (New York, U.S.A.). Once digitized, the cross section at the midshaft of each rib was extracted using the software Amira 5.4.0. The Min. Ar. Mid. was quantified by Fiji software while the Sh. Mid. was measured using 2D geometric morphometrics in Viewbox 4 software. Eventually, the covariation between both parameters was studied by running a linear regression using MorphoJ software.

The results show that the Min. Ar. Mid. and the Sh. Mid. covariate in the typical ribs such that ribs with a rounded Sh. Mid. will have a larger Min. Ar. Mid. than ribs with a mid-laterally flattened Sh. Mid. This relationship can be extrapolated to a comparative analysis where it is observed that mid-laterally flattened Sh. Mid. and low Min. Ar. Mid. is related to *H. sapiens*' typical ribs while rounded Sh. Mid. and large Min. Ar. Mid. is related to *P. troglodytes*' typical ribs even though chimpanzees may also have typical ribs with a human-like pattern. In addition, it can be seen that Sts-14 ribs' pattern of covariation is similar to that of *P. troglodytes*. Nevertheless, the correlation between the Min. Ar. Mid and the Sh. Mid. is not observed in atypical ribs (costal levels 1, 2, 11 and 12, also 13 in *P. troglodytes*) due to the contrast between their mid-laterally flattened Sh. Mid. and their high Min. Ar. Mid.

The pattern of covariation between the Min. Ar. Mid. and the Sh. Mid. in the typical ribs could be a response to the different thoracic biomechanical needs of *P. troglodytes* and *H. sapiens*. The non-bipedal posture of *P. troglodytes* causes the weight of the head, neck and upper trunk to go through the ribs to reach the upper extremities. Furthermore, since their breathing is hypothetically diaphragmatic, it can be said that chimpanzees' ribs are subjected to greater mechanical stress than those of *H. sapiens* due to their bipedal posture and pulmonary respiration [1,2,4]. This makes *P. troglodytes* ribs need a larger Min. Ar. Mid. to resist the strong muscular activity [1] and a rounded Sh. Mid. to make it structurally possible. The fact that some chimpanzees' typical ribs follow a human-like pattern of covariation could be explained by differences in weight or sex in the tested individuals, but further research would be needed about this hypothesis. Even though the correlation between the Min. Ar. Mid and the Sh. Mid. in Sts-14 ribs is associated to that on *P. troglodytes*, it should be questioned whether inferences can be made from this result about the similarity of their ribcages due to ontogeny since it is proposed that Sts-14 is not fully adult [5].

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Functional wear in the Aboriginal from Yuendumu: A longitudinal study

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Dental wear is a gradual and physiological process that consists of loss of tooth structure, which in turn alters the primary crown surface morphology. The analysis of dental wear, at both the microscopic and macroscopic scale, is one of the most widely used tools in archeology and anthropology to reconstruct the diet, culture, and lifestyle of past human populations [1]. To date, there are no comprehensive longitudinal studies that have examined functional molar wear variation in modern humans. The aim of this study is to provide a set of longitudinal quantitative data within a functional context obtained from the analysis of molar macrowear patterns of children and young adults based on the Occlusal Fingerprint Analysis method [2]. We examined the mixed dentition of Australian Aboriginal children taken from the Yuendumu dental collection, which is housed at the Adelaide Dental School at the University of Adelaide. This is one of the most widely studied dental collections in the world, created from a unique longitudinal research project, where anthropologists annually examined the dentition and growth of Aboriginal children and young adults from Yuendumu in the Northern Territory between 1951 and 1971 [3]. This indigenous population was at an early stage of transition from a nomadic and hunter-gatherer way of life to a more settled existence, with limited contacts with Europeans. Their dentition was mostly characterised by a normal occlusion, with little evidence of dental caries, tooth crowding, malocclusion, molar agenesis and periodontal disease. For our study, we selected nine pairs of dental casts (taken annually from ages 8 to 17), including both upper and lower arches, belonging to the same individual. The dental casts have been surface-scanned using a white-light scanning system with a xy resolution of 45 μm (smartSCAN3D C5, Breuckmann, GmbH).

Our results suggest that the occlusal macrowear patterns of this individual did not significantly change through time. Occlusal contact parameters such as functional area, inclination and directional data, remain relatively unaltered throughout childhood and young adulthood, indicating little changes in the masticatory function of this individual. This could be related to a compensatory mechanism of the human dentition to resist any changes that could disturb masticatory efficiency. To date, there are no studies in modern humans that demonstrated that dental functionality is maintained through time even in more advanced wear stages. Only a few dental topographic studies in non-human primates have shown that masticatory efficiency is maintained throughout the wear sequence [4]. Thus, tooth wear seems to generally keep teeth mechanically efficient for fracturing specific foods during the lifetime of an individual. Biomechanical studies have indicated that tooth wear helps to dissipate the mechanical load over the crown surface, thus reducing tooth failure throughout the lifetime of an individual [5].

Our current study was limited to the analysis of one single individual, and did not include information about advanced wear stages. As such, future studies could investigate if masticatory function in modern humans is maintained throughout the wear sequence by employing larger sample size, ideally from populations with different dietary habits. Furthermore, biomechanical analyses could provide additional information about the effect of age and maturation on masticatory efficiency.

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Neanderthal occupations in Southwestern Portugal: Predictive Models using GIS

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Southern Portugal has a high lithological diversity, which is reflected in the richness of its geomorphology [1], constituting an attractive place for the communities across the Late Pleistocene. Research on the Middle Paleolithic in the region has been punctual. However, since the end of the 20th century the situation has been reversed and several works have emerged in the westernmost areas. Namely, through the project "The Paleolithic Human Occupation in the Algarve" [2,3] which resulted in a set of archaeological sites attributable to the Middle Paleolithic, enriching the available dataset. The mobility of these communities would be around the Atlantic coast (not exceeding 10 km), rivers, lakes and seasonal lakes, however, it should be noted that the models on the settlement patterns established for Neanderthal communities are essentially hypothetical. So, in order to contribute to the development of the study of this period and to fill the existing gaps, this poster displays how the settlement patterns during the Middle Paleolithic in southwestern Portugal were influenced by the local ecology and geology. The main goal was to identify areas with higher probability of occurrence of new Middle Paleolithic sites and to establish a set of cartographic and numerical data that allowed to complement the knowledge about the systems of exploration and occupation of the territory. In this sense, the results of the creation of an Archaeological Predictive Model through the binary addition method are presented. This relied on a statistical, descriptive, and univariate methodology, using dependent variables (archaeological sites) and independent (lithology, altitude, slope, topographic position index, water courses, distance to the coastline) [4]. In a first phase, the cartography of the region was collected, which allowed the creation of the Digital Terrain Model, and the respective thematic mapping (e.g., slope maps, slope orientation, radiation, and sun exposure). After the selection of variables, statistical studies were carried out, such as analysis of internal variability of archaeological and landscape data, establishment, and test of relationships, as well as the exclusion of independent variables that contained redundant information. The results of the statistical tests indicated that the independent variables that had more weight in the location of the archaeological sites were the slope orientation, the topographic position index, and the nearest watercourse order. However, it should be noted that the reduced number of sites influenced the results of the statistical tests, since only three variations showed satisfactory results [5]. Still, the creation of the MPA helped to understand what data should be considered for carrying out future works of the same kind, as well as errors to avoid.

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The postnatal ontogeny of the modern hominoid lumbar vertebral morphology – insight into the development of postcranial sexual dimorphism

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Hominoid presacral vertebral form reflects phylogeny, body size and sexual dimorphism and locomotion. How differences are established pre- and postnatally under the influence of these factors is not fully resolved. This study investigates whether or not modern hominoids share modes of variation in the presacral spine during their postnatal growth and development. We also explore the influence of sexual dimorphism on these ontogenetic trajectories. For this purpose, the spine is analysed using a 3D geometric morphometric approach that allows our analyses to track and compare the interactions of size, age and sex over time, within and between taxa and over multiple vertebrae.

We analysed the five last presacral vertebrae of cross-sectional age series of *Homo sapiens, Pan, Gorilla, Pongo* and *Hylobatidae* spanning all stages of the postnatal period to assess patterns of metameric variation of the presacral spine. 62 landmarks were located on 1572 individual vertebrae. First, the mean size and shape of each vertebra in each species and age group (and where relevant both sexes) was calculated by Procrustes analysis (GPA) followed by rescaling. Then, the five presacral vertebral mean sizes and shapes of each group were best fitted against each other by translating and rotating but not scaling, to preserve their size and shape differences. Next, the whole cloud of points representing the fitted sizes and shapes of the presacral vertebral columns of each species, each age group and each sex (where relevant) were submitted to GPA followed by a PCA of shape variables and the ln of centroid size (form space analysis). The resulting PCA represents each presacral column in each age group in each species (and sex if relevant) as a single point in the form space. In each species points representing successive age groups form an ontogenetic trajectory in size and shape of the presacral spine. Between species or sexes, these trajectories can be compared.

PCA of all taxa shows that PC1 is highly correlated with centroid size and reflects both age differences within species and size differences among them. Form space PC2 separates the human ontogenetic trajectories from those of apes while PC3 distinguishes the hylobatids. *Gorilla*, with large lumbar vertebrae and *H. sapiens*, with large vertebrae relative to body weight have longer ontogenetic trajectories than the other apes. In markedly size dimorphic taxa (*Gorilla, Pongo*), vertebral size dimorphism is established through extended ontogenetic trajectories. PCA of sexual dimorphism shows that in humans, female and male vertebral form starts to diverge in juveniles. In females, the vertebrae are bigger, with a longer body and inferior articular processes. However, human male subadult and adult vertebrae become bigger than female ones and the vertebral bodies are deeper and wider with longer costal processes. In great apes, female and male vertebral size does not differ much until the subadult stage, when male vertebral form, particularly in the highly sexually size dimorphic taxa (*Gorilla, Pongo*) starts to deviate from the female. The differences in vertebral morphology are scaled between the sexes from subadults onward, with males bigger. Although limited sexual dimorphic variation in vertebral size and morphology is expected in *Hylobates*, the sample is not adequate to assess it in every age group.

Despite the differences in locomotion among Asian and African apes, dimorphism follows a similar pattern. It is interesting to note that the two taxa with the most distinctive locomotion within the hominoids – *Homo* and *Hylobates* deviate most in lumbar ontogenetic trajectories. Understanding postnatal ontogenetic transformations and how they lead to differences in adult size and shape of the lumbar spine are important in interpreting fossil hominin vertebrae, particularly in relation to retrodiction of locomotion and in comparing ontogenies in relation to understanding how adult form arises.

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Retouch-induced marks on Australian hardwood boomerangs: A preliminary analysis

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Retouchers – organic implements used for shaping the edges of lithic tools – are among the most ancient bone tools in existence. In Europe, they were mostly made from the butchered remains of large herbivores, and were present in the human toolkit through the entire Palaeolithic, with several experimental studies clarified the use of these tools by means of a percussion movement. A different situation is observed in Australia; here, although a great number of stone tools are retouched, bone retouchers are apparently absent from both the material culture and the literature, and no systematic study of organic-based retouch activity has been carried out.

A systematic review of observations regarding the Indigenous Australian population over the past 150 years found the utilisation of an unsuspected implement as retouchers: the wooden tools. In fact, several ethnographic accounts recount the employment of hardwood boomerangs, wooden blades, or simple wooden sticks as retouchers by means of percussion movements. These references to retouching on the Australian continent seem to appear only within the description of other daily activities – especially woodworking.

We present the analysis of a sample of hardwood boomerangs collected among different communities in Australia, revealing the presence of retouch-induced marks on the surface of boomerangs. Such marks are easily recognisable and linkable to those observed on the bone surface of European retouchers. These results will allow the identification of organic retouchers in Australian contexts, and for the first time, a systematic study of retouch activity in Australia's deep past. Moreover, among the ethnographic reports, it is often observed that tools with an apparently very specific function (e.g., hunting or fighting boomerangs) are also used as retouchers. This evidence leads to a concept of multifunctionality of some organic tools among hunter-gatherer communities, which should be further explored in relation to Palaeolithic human groups.

The analysis of the boomerangs, and their comparison with the Palaeolithic bone retouchers, will lead to the study of the retouch activity from an ethnoarchaeological perspective. Bone and wood share several biomechanical features, and it is not surprising that they could be interchangeably used for the same retouching purpose, over a timeframe that spans from the Lower Palaeolithic to the eighteenth century.

The Middle Paleolithic sites of Brive-Laroche-Aérodrome and their lithic assemblages: A new key-site for the understanding of Neanderthal movement dynamics and technical behavior in Southwestern France

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Southwestern France is an area well known for their numerous Middle Paleolithic occupations, as evidenced by the eponymous site of Le Moustier or other major sites such as Combe-Grenal or La Ferrassie among others. However, these sites are almost all located in a small area between the Vézère and the Dordogne valleys. Although a few sites have been excavated in neighboring areas, the Brive Basin remains an almost unknown territory for the Middle Paleolithic. The best known sites in Corrèze are those of la Chappelle-aux-Saints and Chez-Pourré Chez-Comte, both in caves. We report here a new evidence of Middle Paleolithic occupation in the department with the open-air sites of Brive-Laroche-Aérodrome, which was discovered during diagnostic operations [1] and excavated in 2019. Two areas were excavated, yielding lithic materials corresponding to distinct occupations (BLA-Nord, BLA-Sud). Geomorphological and spatial analyses suggest a complex taphonomic history of the archaeological assemblages. We present here the main results of the technological analysis including refits and combined with the raw materials characterization. The objective is to highlight the techno-economic behaviors present in these two occupations and to place them in their regional context. BLA-Sud site has yielded 972 lithic pieces. Although it could be a palimpsest, homogeneous technological behaviors corroborated by refits (refits rate=9%) have been identified, with the main exploitation of local raw materials (quartz from the Corrèze and Dordogne alluviums) and an exogenous flint component. Knapping systems are typical of the Middle Paleolithic for these materials (centripetal exploitations, e.g. Levallois, Discoid and Cores-on-flakes). The reduction processes are fragmented and ramified. A broader diversity is perceptible for the quartz assemblage, with S.S.D.A., bipolar on anvil and Discoid debitages.

The lithic assemblage of BLA-Nord is for its part composed by 340 lithic pieces. The archaeological material was unearthed on a smaller area surrounded by blocks. This layer seems spatially less disturbed than the other (refit rate=13.2%). Local quartz are also mostly employed for knapping but the flint component is quite important (up than 30%). Debitage concepts identified are more standardized than in BLA-Sud, with hierarchized systems associated with more standardized end-products on quartz. Levallois is attested on flint as well as cores-on-flakes. As for BLA-Sud, flint reduction processes are fragmented and ramified. A clear raw material economy exists, as all the tools identified are in flint (scrapers, Mousterian points). These exogenous materials (≈15-50 km) were collected mainly in the Western area (outcrops near Montignac, Tamniès) but also in the Southern area (Turenne, Gramat).

The two lithic assemblages allow us to better understand the dynamics of occupation of the Brive Basin and their relationships with surrounding areas during the Middle Paleolithic. The main use of quartz enables us to highlight once again the variability that exists within the Mousterian techno-complex and the adaptability of Neanderthals to their environment. The techno-economic behaviors identified are comparable to those of other neighboring zones where metaquartzites dominate such as Les Fieux, Le Mas Viel or Pradayrol [2]. The adaptation to local raw materials constraints and the diversity of flint identified appear as typical features of these late Middle Paleolithic sites.

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Concerning macro- and micromorphological variability of fossil human distal phalanges from Pleistocene Altai caves

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In the absence of larger long bones, distal manual phalanges can serve as a source of valuable morphological information. The goal of this study is to describe morphological variety among Altai fossil specimens, by comparing the four distal phalanges of rays 2–5 from the Denisova, Chagyrskaya and Strashnaya Caves.

Based on morphological criteria we tested a hypothesis about the presence in the Pleistocene Altai of hominids of differing origin and, in particular, the existence of distinctive morphological variants among Neanderthal settlers of Altai. Manual distal phalanges were measured, X-ray filmed and scanned before sampling for ancient DNA extraction. Scanning was performed using an X-ray microscope, whose imaging resolution is sufficient to combine traditional radiological methods with non-destructive microscopy. Xradia software was used to create 3D models and virtual cross-sections, and also to measure osteons. Comparison was made of cross-sections of the dorsal compact bone at midshaft. The percentage of the cortical area (%CA) was estimated at midshaft level, and calculated as a ratio of cortical area to total area of the diaphyseal section. In addition, digital micro-focus radiography of all objects with magnification was performed.

Our results show high morphological diversity among the Upper Pleistocene population. Three of four studied samples were identified as Neanderthals (Denisova 9, male (?) [1], Chagyrskaya 08 and 56, females) by long, wide and flat diaphysis, and a wide and rounded apical tuft.The phalanx Strashnaya 4 features anatomically modern traits and does not correspond to Neanderthal specimens in proportions or dimensions. It is short with relatively narrow and tall diaphysis. Radiological examination reveals two different morphological variants present in Altai Neanderthals from Denisova and Chagyrskaya. Phalanges show substantial changes in internal structure. In the distal half of Denisova 9, the space of the medullary canal was fully displaced by osteonised tissue, resembling a variant of the “ivory” epiphyses - in particular distributed among modern humans of African ancestry [2, 3]. Denisova 9 joins with the modern human Strashnaya 4 by high corticalisation at the midshaft (%CA 92,85 and 82,61 correspodingly). Chagyrskaya 08 and 56 are thin-walled (%CA 58,77 and 30,88). Non-destructive radiological microscopy revealed further differences among the samples: greater and denser bone mass in the case of Strashnaya 4, low mineralised compact of all Neanderthals. In the middle portion of the dorsal compact at the midshaft level, Denisova 9 has large and low mineralised secondary osteons with relatively narrow Haversian canals. Both these Neanderthals from Chagyrskaya show smaller osteons, low density of compact tissue, larger Haversian canals. Strashnaya 4 has thick and very dense, highly mineralised compact with diameters osteons broadly matching those in the two Neanderthals of Chagyrskaya but with narrower Haversian canals. Conclusion. The data may indicate the presence among Altai groups of Neanderthals who differed by origin, and/or chronologically. Patterns of Denisova 9 can be discussed in the context of his hybrid ancestry.

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Typo-technological analysis of a bifacial stone tool from Cueva de los Toriles (Carrizosa, Castilla-La Mancha, Iberian Península) and its importance as a new Acheulean site from the Southern Iberian Plateau

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The study of the Paleolithic period in Inner Iberia, specifically between Tajo and Guadiana's basins, has always been a pending matter in the archaeological historiography. This lack of evidence is even greater when we approach more recent Pleistocene chronologies [1]. This part of the Iberian Peninsula has traditionally been thought to be practically inhabited during most of the Paleolithic, and even nowadays is the prevailing paradigm [2]. Toriles' Cave, along with other archaeological sites nearby with similar industries [3], has come to make us rethink the present hypothesis and fill the emptiness of the past researches.

The stone tool was found in a stratigraphic position associated with travertine levels of high calcium carbonate precipitation. The raw material is a fine-grained quartzite (64x41x17 mm, 38.32g), probably, made on a flake, but the ventral surface is barely outlined. The dorsal surface is shaped as a convergent scraper with an invasive bifacial retouch on the left edge and a unifacial retouch on the right edge. The butt of the striking platform is characterized by the large presence of reflected negative scars. The left edge retouch has plain and invasive negatives scars that are reflected in the middle of the tool. Attending the technological attributes described above, the bifacial tool can be classified as an almond-shaped handaxe or as a bifacial convergent *racloir*. The techno-typological and functional analysis of the bifacial stone tool has been developed by the Prehistoric Technology and Archaeology Laboratory of the CENIEH (Centro Nacional de Investigación sobre la Evolución Humana).

Techno-typological, taphonomical, and functional analyses showed that the lithic tool could be attached at the final Acheulean or Mousterian periods. For this reason, we consider that the chronological range of the lithic tool is 300-120 kya, but the travertine dates will corroborate it.

Previous research suggested, based on the evidence of the primitive species of badger *M. thorali* [4], the potential presence of some Pleistocene deposits into Cueva de Los Toriles. Our results highlight also the importance of this site as a previously unknown Acheulean archaeological site. The fossil and archaeological record in the southern Iberian plateau is particularly scarce compared with other regions of the Iberian Peninsula [5], but it is crucial to understand the pattern of population mobility between the north and the south of the Peninsula and thus its population during the Pleistocene. Future excavations in Cueva de Los Toriles, combined with absolute datation of stratum where the tool was found, will contribute to filling this gap of knowledge.

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Attesting Neanderthal Dwelling Space Use: effects of human occupations in the Middle Palaeolithic record of Fumane cave (Verona, Italy) — ANDSU Project

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The debate over Neanderthal subsistence patterns and behavioural aspects is a source of many discussions and scientific contributions. Research over the last ten years has produced new data on mobility, economic strategies and life-aspects of these ancestors, changing and enriching the comprehension of their material record. This project will address the identification of changes in Neanderthal subsistence patterns, across the late Mousterian sequence of Fumane cave (44-47.6 ka cal BP), one of the most important European key-sites (Verona, Italy).

ANDSU will attempt to overcome some of the current scientific limitations, by focusing on specific objectives: the identification of Neanderthal's spatial alteration patterns; the durability of their occupations; the site function; the temporality (or not) of site space and the lengths and number of occupation(s)/event(s). An integrated multidisciplinary research methodology will be harnessed to address these objectives and enhance the state-of-the-art. The project's innovative methodology will include bone refits, spatial archaeology, multivariate statistic techniques (k-mean cluster analysis; hierarchical classification methods; discriminant and point pattern analysis) and 3D model reconstructions. The experimentation of bones' 3D scan will be an excellent way to record and transfer scientific information. The ability to automate or semi-automate refits of large faunal assemblages would add new perspectives to zooarchaeological research methods.

According to current literature and the growing evidence emerging from many European sites, this project could provide useful data on the late Neanderthal groups. Moreover, it focuses on the crucial need to extend our knowledge on Neanderthal's behaviour and settlement patterns i.e., Fumane inhabitants' life-ways and their cultural relationships. ANDSU will serve as a foundation for further studies, enabling a collection of data that can be applied to the construction of populations models and eco-cultural niches of other European regions.

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Reopening a grave: Preliminary taphonomic results of the human remains from the Roc de les Orenetes site (Queralbs, Spain)

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Collective burials are one of the main funerary practices carried out in Europe between the Neolithic and the Bronze Age. In the northeast of the Iberian Peninsula, natural caves are frequently used as sepulchres since the Early Neolithic (ca. 7.700 – 6.500 yrs. cal BP) [1]. Roc de les Orenetes is a cave located near the village of Queralbs (Spain) at 1860 m a.s.l. in the Catalan Pyrenees, where a collective burial from the Bronze Age was found. The cave was discovered in 1969. In 1973 the professor Eudald Carbonell performed some test pits on the outside of the cavity and collected remains from the surface inside the cave, providing a first description of the site. In total, more than a thousand archaeological remains were collected, including human, faunal, pottery, and metals fragments. A minimum of 32 human individuals were identified [2] while pottery and metal artefacts suggest the use of the cave during the Bronze Age period (4.300 – 2.700 yrs. BP) [3]. After the intervention, the access was sealed to prevent damage from clandestine incursions. In 2019, almost 50 years later, the cave was reopened to new archaeological research in the frame of the ARRELS project granted by the Government of Catalonia (ES) (code CLT009/18/00048). A first small test pit (1.5x1 meters) inside the cave provided new 809 remains, including human and faunal bone remains, pottery fragments and charcoals remains (stratigraphic units 4 and 5). This new assemblage provided the opportunity to investigate the taphonomic features of human assemblage. Our main objective is to determine which taphonomic agents are mainly responsible for the disarticulation, dispersion, and fragmentation of skeletal remains, combined with the anthropological study of the recovered remains. This approach is framed within the discipline of Forensic Taphonomy, which focuses on the modifications that have occurred on bones from the individual's death to the present day [4],[5]. The bone surfaces were examined macroscopically, using a stereomicroscope to document the taphonomic modifications, following the criteria of different researchers. The fracture patterns of the bones, as well as the carnivores' tooth marks, were compared with several archaeological and experimental studies. Our first results suggest that complete human bodies were deposited inside the cave. All skeletal elements are represented, including small bones and those first to disarticulate after decomposition of soft tissues. Carnivores constitute the main taphonomic agent in the disarticulation and fragmentation of bones. The access of these animals on the bodies will give us information about how the individuals were deposited inside the cave. Besides, bones are also highly affected by biochemical corrosion. The forthcoming excavations, radiocarbon dating, and analysis of the new findings will also allow us to know if the cave was used as a burial space at more than one moment in time, beyond the Bronze Age. Taphonomic studies of human bone accumulations are still not very common, but they allow a holistic understanding of human bone accumulations and are especially important in the case of fragmented and commingled remains. Roc de les Orenetes represents an example of a sepulchral cave site re-opened to new research involving cutting edge and frontier methodological approaches, as the study of funery human behaviour from a taphonomic perspective.

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Virtual reconstruction and geometric morphometric analysis of the mid-Pleistocene hominin KNM-OG 45500 (Olorgesailie, Kenya)

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KNM-OG 45500 is a hominin fossil composed of parts of a frontal bone, left temporal bone, and cranial vault pieces. Since its discovery along the Olorgesailie Formation (Kenya) in 2003, it has been associated with the *H. erectus* hypodigm [1]. The specimen, dated to ca. 900 Ka BP, has been described as a very small adult individual of probable female sex. However, despite its status as an important hominin specimen, it has not been used in a quantitative comparative framework because of its fragmentary condition, thus overlooking important information in depicting human evolution at this crucial time period [2].

Here, we undertake a virtual reconstruction of the better-preserved fragment, the frontal bone and apply geometric morphometric analyses, using a geographically diverse fossil (n=20) and modern human (n=30) comparative sample, in order to investigate the morphological affinities of KNM-OG 45500. The frontal bone was mirrored along its sagittal plane to reconstruct the left preserved structures on the right side and *vice versa*. We collected a total of 80 landmarks on the reconstructed frontal squama. After generalized Procrustes superimposition, we analyzed the aligned coordinates, centroid size distribution, and pairwise Procrustes distances between specimens using different methods, such as principal component analysis, cluster analysis, and correlation tests. Our results show that the frontal shape of KNM-OG 45500 exhibits similarities with Early Pleistocene fossils from Eurasia and Africa that are assigned to *H. erectus* sensu lato (s.l.). Its size, on the other hand, is among the smallest in our sample. KNM-OG 45500 is notably smaller than most other fossils from similar chronological age (i.e. Daka BOU-VP-2/66). Its size is comparable to the specimens from Dmanisi (Georgia) and to H. naledi. Such small morphology, if not related to ontogeny, seems to confirm possible high sexual dimorphism in *H. erectus* s.l.[3]. Taken together, our analyses of the frontal bone suggest a taxonomic attribution of KNM-OG 45500 to *H. erectus* s.l. and extend even further the range of size variability associated with this taxon around 900 Ka BP. The new reconstruction, moreover, will allow comprising this specimen in future research on hominin frontal bone anatomy.

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The stratigraphy of Cave 1B at Klasies River Main site, South Africa: clarifying the context of the KRM 41815 human mandible

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The hominin fossils excavated from the Middle Stone Age deposits at Klasies River Main site have contributed significantly to understanding the anatomy of early modern humans between ~120 ka and ~60 ka [1,2]. The sample of more than 50 published specimens was recovered during two separate phases of excavation in 1967–1968 and 1984–1995 which were conducted at very different scales of stratigraphic resolution [1,3]. The morphological variability of the published specimens and their distribution within the deposits suggest the presence of a diverse population which displayed a mix of modern and archaic traits [2]. Evidence for the processing of some of these remains and the recovery of some specimens in close association has led to the argument that the majority accumulated at the site in a few short events in which several individuals died (perhaps through violence) and were cannibalised [3]. One of the most complete specimens from the site – the mandible designated as KRM 41815 – was recovered from Cave 1B during the initial excavations. It is relatively robust and has featured prominently in debates about sexual dimorphism and archaic *versus* modern morphologies in the population/s which occupied the site [2]. Despite its significance, little published information is available on its context. It was assigned to the top of Layer 10, one of 15 spits that were described and illustrated in little detail by John Wymer [1]. Based on the subsequent higher-resolution excavation of square PP38 on the edge of the original excavation, the Cave 1B deposits were placed within the Light Brown Sand (LBS) and Shell and Sand (SAS) Members which also occur in Caves 1 and 1A, and are associated with MSA I and MSA II lithic assemblages respectively [4,5]. However, the sequence was not described in any detail and no stratigraphic drawing or photograph was published. Correlations between the PP38 lithostratigraphic units and the original layers were later published without evidence or discussion, equating the LBS to Layers 12–15, and the SAS to Layers 11–1 [5]. Layer 10 was initially correlated with the Rubble Brown Sand (then considered a sub-member of the SAS) in Cave 1 [4] but was later argued to be contemporaneous with the earlier phase of the SAS [3]. The latter interpretation potentially links KRM 41815 to a hypothesised event involving the death and cannibalism of multiple individuals over a period of a few weeks [3]. Field descriptions of the PP38 deposits are presented here for the first time. This information is used (along with published and unpublished descriptions and stratigraphic diagrams from both excavations) to correlate this sequence with the 15 layers of the original excavation and potentially provide greater clarity on the context of the mandible. The results reveal a number of inconsistencies in the published correlations. The most significant of these is the difficulty of reconciling the published descriptions of Layers 10, 11 and 12 with the observed properties of the lithostratigraphic units in PP38 with which they have been correlated. A revised interpretation is presented accordingly.

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The origins of modern human cultural know-how

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Cultural repertoires are sustained by social learning mechanisms that involve learning from and via others [1]. There exist different types of cultures, which rely on different learning mechanisms. On the one hand, "copying social learning" (copying, such as imitation) allows for the transmission of behavioural forms themselves (i.e. the know-how) between individuals. Likewise, environmental products such as artefacts can also be copied from a model via so-called emulation. On the other hand, "non-copying social learning" such as local or stimulus enhancement allows acquiring information about the context of a behaviour, but they do not transmit behavioural or artefact forms. The behavioural form must therefore be acquired in a different way, namely via individual innovation [2].

Cultures that rely on copying consist of culture dependent forms, which need to be acquired by observation of a model's behaviour or artefacts. Culture dependent forms are the defining feature of human culture. Cultures that do not rely on copying consist of culture-independent forms (latent solutions), which any individual from any population of the same species can learn on their own, without observing a model or its artefacts [2]. Whether or not a given individual shows a latent solution depends on a complex interplay of factors including motivation, environmental conditions and age. Importantly, the likelihood of showing a latent solution is also often heavily influenced by non-copying social learning mechanisms [3].Therefore, even behavioural repertoires only constituted by latent solutions can still be cultural (in a minimal sense) as social learning plays a role regulating the frequencies of expressed latent solutions.

There is growing empirical evidence that both non-human great apes and modern humans possess latent solutions in their repertoires. However, only modern humans have been conclusively shown to also include culture dependent forms in their repertoires. Consequently, it is still under debate what the earliest instances of culture dependent know-how were in our lineage. Detecting the first instance(s) of culture dependency would help elucidate the factors leading to the origins of human culture. In order to identify the earliest instance of culture dependency it is necessary to evaluate if pre-modern hominin behaviours were dependent or independent from copying. To this end, our lab employs baseline tests in which individuals naïve to the target behavioural or artefact form are provided with the necessary raw materials to perform a behaviour or create and use an artefact in the absence of any copying opportunities. If the behaviour/artefact emerges in these tests, it must be possible to individually learn its form – which makes it a latent solution. However, note that this does not deny the possibility that non-copying social learning regulates the likelihood of expressing the particular latent solution.

We have started to apply this methodology to pre-modern hominin technological behaviours. Given that it is not possible to test hominins directly, we use our closest extant relatives, the great apes, as phylogenetically-relevant models and as general models of tool-using species. In the first application of this methodology we have been able to show that the use of tools to excavate can be a latent solution [4]. This result suggests that the last common ancestor of Homo and Pan (7 Ma) could also have learned to use excavating tools without the need to copy others. This methodology will likely continue to help reveal when copying and culture dependent forms first evolved in our lineage.

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Exploring the diet of the Late Pleistocene population from Taforalt (Morocco, North Africa) using Zn, C, N and Sr isotope ratios

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The site of Taforalt is currently the oldest known cemetery in North Africa [1], yielding numerous human remains dating to the Iberomaurusian period (15 000 ka cal.BP) from all age classes including adult, adolescent and infant individuals. The diet of this population is known mostly from archaeological data, and consisted of animal products (mainly Barbary sheep), plants as well as land mollusks. In order to quantify the importance of each food category in the diet of these late Paleolithic individuals and to assess the intra-population diet variability, we conducted isotope analyses. In this environmental context collagen is difficultly preserved. Therefore, we used the new isotopic tracer Zinc ($^{66}Zn/^{64}Zn$, expressed as $\delta^{66}Zn$ value) from tooth enamel bioapatite. This isotope trace element constitutes a promising trophic level indicator, alongside with the traditional carbon and nitrogen from dentine collagen. Additionally, we applied the radiogenic strontium isotope on human and animals coming from the same site in order to trace the mobility and the geographical provenience of the food consumed by this group. These trace elements are analyzed using the multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS).

A recent study showed that Zn could be used to trace dietary transition in childhood, as the teeth formed in utero and in the first years of life tend to exhibit higher Zn isotopic ratio than the teeth formed after weaning [2]. By analyzing different types of teeth (deciduous and permanent) formed at different stages of life, we aim to highlight some life aspects of this population, like the length of the breastfeeding period and weaning age. The weaning age is believed to have a strong impact on the birth spacing, demographic growth and the mortality rate within a population [3]. Therefore, we will compare our results with data of individuals coming from other archaeological contexts where dietary changes during childhood were observed (eg. the site of Lapa Do Santo in Brazil).

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The Evolution of Pyrotechnology in the Early and Middle Upper Paleolithic in Europe

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The use of fire is a hallmark of the genus *Homo* and considered as one of the most important technological innovations in hominin evolution. Much of archaeological research has focused on the origins of fire use and its role in early human evolution. While the use of fire is commonly seen as an essential part of past hominins' toolkit, the question of when fire started to be habitually used has been recently debated [1], [2]. Most available research tends to target the spatial distribution of hearth-related assemblages, with fewer studies focusing on characterizing the nature of the fire features themselves – i.e. pyrotechnology. Consequently, we currently lack a clear understanding of how pyrotechnology changes even in later periods such as the Upper Paleolithic.

Here we report on our ongoing research into pyrotechnology of early anatomical modern humans in European contexts. We performed a comprehensive review of published data on frequency and variability of fire features associated with Initial Upper Paleolithic (IUP), Aurignacian and Gravettian technocomplexes (∼45,000 to ∼25,00 years BP). Our review currently gathers metadata from 122 archaeological sites spanning from Eastern/Central Europe (Ukraine, Russia, Moldova, Serbia, Croatia, Romania, Poland, Slovenia, Slovakia, Hungary, Greece, Czech Republic, Austria, and Germany) to Western Europe (France, Spain and Portugal). Databased construction was based on a series of criteria targeting the nature of fire features, namely: rate of recurrence of features per site and per layer; description of feature shape and dimensions; presence of superimposed fire events; nature of combustion feature microstratigraphy and contents (ash, charcoal, char, phytoliths, burned bones, burned lithics); and degree of preservations of each feature. Data was ranked into four categories depending on the type of resolution available, those being category 0 - no evidence for fire, 1 - indirect or limited data, 2 - direct data with detailed field descriptions, and 3 - available high-resolution data.

Our results show that one of the main obstacles for analyzing pyrotechnology is the lack of standardization of descriptions on fire residues. While burned remains or presence of combustion features are commonly mentioned, there is limited contextual data provided on the fire features (n=114). Very few sites (n=8) have published contextual or high-resolution data (category 3), and even fewer present site formation analyses (e.g. micromorphology) of fire residues. This lack of research into the nature and composition of fire residues limits our ability to look at regional and temporal trends. It also highlights the need to establish standardized reporting on fire evidence from archaeological contexts. Despite these limitations, our ongoing study points to relevant variations in pyrotechnology during the early and middle Upper Paleolithic record. The vast majority of IUP and Aurignacian data is dominated by open combustion features lit on unprepared surfaces, like those described for Neanderthal contexts [3], [4]. However, the Aurignacian record also shows innovative aspects of pyrotechnology, namely the emergence of prepared burning surfaces and pit structures from sites such as Klisoura Cave, Abri Pataud, Abri Castanet, Abri Cellier, Regismont le Haut, and Galgenberg-Stratzing. Similar features are found within Gravettian occupations across Central and Eastern Europe, with an increasing prevalence of associated features (that is, features in proximity to open hearths) such as boiling pits and prevalent ash dumps as well as the creation of kiln-like structures. In all, our results show an increasing structural complexity in pyrotechnology associated with the Gravettian and highlight the need for more standardized high-resolution data to better understand the evolution of pyrotechnology in the Upper Paleolithic.

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Preliminary results of the first lithic raw material survey in the piedmont zones of Kazakhstan

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As the study of lithic raw materials has grown in importance, this method has begun to reveal new aspects of technological evolution within prehistoric communities. In the last few decades, the study of raw materials has tended to focus mainly on hominin mobility strategies, provenance, land use patterns and raw material transfer to farther distances. Examples of such transport behaviour are known throughout the Middle and Upper Palaeolithic complexes of Europe [1] and some evidence is known in Central Asia [2]. However, systematic studies of raw material sourcing have not been undertaken for the Palaeolithic of Kazakhstan, such survey being embedded in reconnaissance surveys aimed at discovering new Palaeolithic sites [3].

The current study presents the preliminary results of the first lithic raw material survey in the selected study areas of Kazakhstan. We aim to distinguish (1) the geographic use patterns of raw materials and (2) their correlation with the lithic assemblages of the stratified sites in the piedmont and foothill zones of Kazakhstan. The study is based primarily on the surveying of outcrops, collecting and sampling of any potential sources of raw materials, and also on a substantial literature review. In addition, the CERCAMS database were employed to locate occurrences of individual types of rocks [4]. Here we describe primary and secondary sources of raw materials identified during the survey, and compare them macroscopically with the available assemblages of stone tools. The survey results show heterogeneous distribution of knappable raw materials throughout the selected study regions. Macroscopic observations of the lithic assemblages and data extracted from literature suggest the selection of locally occurring raw materials by prehistoric groups. Additionally, regional differences in the utilisation of a particular type of raw material which can be observed through the macroscopic examination of the lithic collections are confirmed by survey results.

The current study was conducted within the PALAEOSILKROAD project and conducted all field research under license No. 15008746 (12.05.2015) of the National Museum of the Republic of Kazakhstan based on the collaboration protocol between the Eberhard-Karls University of Tübingen and the National Museum. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n° 714842; PALAEOSILKROAD project).

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Ontogenetic changes of endocranial shape asymmetry in humans and apes

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Brain lateralization is commonly interpreted as crucial for human brain function and cognition. However, given that brains of our closest living relatives, the great apes, are rarely available for study, little is known about which aspects of morphological brain asymmetry are really uniquely human. In an effort to provide a broader comparative framework, we have recently used endocranial casts that approximate outer brain surface asymmetry [1]. We found that the magnitude of asymmetry is comparable among humans and non-human apes and that the main pattern of shape asymmetry, while more variable and less directed in humans, is shared among them. The well-documented combination of a right frontal and left occipital extension of the cortex can therefore not be seen as typically human anymore.

Whereas the tempo and mode of brain growth are the main drivers of endocranial form, it is not known to what extent other factors, such as masticatory muscles, influence endocranial shape asymmetry. Here, we studied ontogenetic changes of endocranial shape asymmetry in humans and non-human apes to further elucidate what we can learn from endocasts about brain lateralization. If functional asymmetry of the masticatory system affects endocranial shape asymmetry, we expect the magnitude of endocast asymmetry to increase during development.

Our cross-sectional ontogenetic samples comprised 135 humans, 107 chimpanzees, 79 gorillas, and 78 orangutans from infants to adults. For each individual, we generated a digital endocast based on computed tomographic scans and measured 935 endocranial landmarks and semilandmarks. The semilandmarks were allowed to slide to a symmetric template so as to gain point-to-point correspondence and to remove asymmetry resulting solely from an asymmetric placing of semilandmarks. To quantify endocranial asymmetry, we used a Procrustes approach among the measured landmark configurations and their relabeled reflections. We found that the magnitude of asymmetry does not change with increasing age or increasing endocranial volume in all four analyzed taxa. The range of magnitude in non-adults overlaps with the range in adults. However, adult orangutans show an elevated range of variation and were on average more asymmetric compared to non-adults. The main pattern of shape asymmetry, including differential projections of the occipital, frontal and cerebellar lobes as well as temporal poles that we had shown to be shared in adult humans and non-human apes, was already established in the youngest individuals in our sample. In contrast to non-human apes, directedness decreased in human postnatal ontogeny. These findings are consistent with the idea that endocranial asymmetry is informative about internal brain development rather than just a sign of an asymmetric craniofacial complex affected by unbalanced mastication.

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Multiproxy approach for studying hunter-gatherer landscape transformations during the Last Interglacial (Eemian) and the Mesolithic in Europe

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The intensity and forms of past hunter-gatherer landscape modifications are still debated. Nevertheless, hunter-gatherer impact on surroundings is crucial for understanding the role of *Homo* in environmental changes. Different types of evidence in the form of proxies for hunter-gatherer impact have specific temporal and spatial resolutions and limitations. The presence or absence of proxies in a sample site depends on research strategy. There is no protocol for the selection, integration and interpretation of multiple relevant proxies when assessing past hunter-gatherer landscape changes. In addition, there is no alternative approach when relevant proxies are not available for such studies. Moreover, human-induced landscape transformations in the Mesolithic are often evaluated from the perspective of later farming societies which occupied the same areas or sites. These later people had different economic structures and tools, which dramatically impacted landscapes. In comparison, anthropogenic impact could be characterised as minimal or absent during the Mesolithic, underestimating landscaping capabilities of hunter-gatherers and possibly skewing our knowledge of "natural" environments. A similar bias exists when comparing the impact of Mesolithic hunter-gatherers with Neanderthal presence in the landscape. Accordingly, this study focuses on the review of relevant proxies and their possible combinations to assess their potential for understanding past hunter-gatherer landscape management. Furthermore, we compare general patterns of possible Neanderthal impact during the Last Interglacial (Eemian) (130,000 – 116,000 BP) with landscape changes induced by modern humans during the Mesolithic (11,700 – 6,000 BP). These time periods are both characterised by interglacial conditions, and similar hunter-gatherer activities would be expected to cause comparable anthropogenic impact.

Ethnographic observations show that (sub-)recent hunter-gatherers can transform their surroundings dramatically. Sub-recent hunter-gatherer niche construction with effects on landscapes include: 1) general modification of vegetation via burning; 2) plant cultivation (i.e. broadcast sowing of wild annuals, transplantation and in-place encouragement of plants and roots); and 3) landscape modification to impact animal presence and their accessibility. These categories are reflected in a long list of proxies from archaeological and environmental records, with varied spatial resolution and preservation over time.

We compare datasets for the Eemian and Mesolithic periods and make the preliminary conclusion that anthropogenic landscape changes during both periods are comparable as far as several proxies are concerned. The available proxies include palynological data, plant macrofossils, charcoal, non-pollen palynomorphs and faunal remains. In the absence of a protocol, data and interpretations from both periods share similar limitations. These proxies suggest that hunter-gatherer impact on their surroundings in both periods could have included burning and indirect (i.e. via changes to herbivore population) transformation of vegetation, as well as preparation of constructions for controlling fish movements during the Mesolithic. We suggest that modelling efforts can aid in further understanding the intensity of human induced landscape changes and variation through time.

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Homo sapiens dental variability during the Holocene in Western Indonesian archipelago

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Human remains dating back to the Early and Middle Holocene in the western Indonesian archipelago are mostly found in habitat and burial sites such as caves and rock shelters at the Southern and Northern mountains of Java, Southern and Western mountains of Sumatra [1], or in sites reflecting human activities like shell midden on the Eastern coast of Sumatra. During the Late Holocene, the natural niches were reused for burial purposes, as it is the case in the exceptionally rich site of Gua Harimau in South Sumatra.

Numerous fossils were discovered in this region during recent years, whose description remains largely unpublished. The present study aims at characterizing the variability of their dental record. The sample includes 218 lower teeth and 207 upper teeth, which are described by means of comparative morphology based mainly on the ASUDAS method [2], comprising 186 non-metric traits on all tooth-types, BL and MD measurements [3], geometric morphometrics 2D [4] on premolars and molars, and also the crown size and cusp proportions [5] of the molars. We furthermore test similarity and differentiation by metric and non-metric statistics analysis in order to observe group clustering among the samples.

Results show two different dental types. The "Preneolithic" one is present on Early to Middle Holocene fossils, between 12 to 4.5 Ka, and displays some derived characters such as a relatively simple occlusal composition such as the 4 cusps with + groove pattern and a smaller size of the second lower molar. The "Neolithic-Paleometallic" type characterizes Late Holocene remains, appear since 3.2 Ka, and shows more 'archaic' features characters compared to the previous one, such as the presence of accessories, 5 cusps with Y groove pattern on the same tooth class.

This study opens new perspectives re. the scenario of human occupation in the western Indonesian archipelago during the Holocene, and questions as well the chronological significance of some features classically described as 'archaic' or 'derived' in dental palaeoanthropology.

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Upper Premolar Crown Variation in Great Apes

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Hominid dental morphology has been studied extensively for its relevance in addressing biological and taxonomic questions. However, great ape dentition is underrepresented in the literature. Particularly, the 3D morphology of premolars is poorly investigated. Also, only few nonmetric dental traits have been described for great ape premolars. The general dental morphological pattern is rather consistent among hominids, yet premolars possess unique, species-specific morphological features. With this study we aim at describing between and within-species morphological variation of upper third (uP3) and fourth (uP4) premolars of extant great apes (*Pan*, *Pongo* and *Gorilla*). Dental material was examined using 3D geometric morphometrics on the enamel-dentine junction (EDJ). To investigate non-metric variation on both the EDJ and the outer enamel surface (OES), we referred to [1] and [2]. We identified 12 traits in our sample for description and statistics. We could include 42 wild and captive specimens from museum collections (26 *P. troglodytes*, ten *P. pygmaeus* and six *G. gorilla gorilla*), represented by both uP3 and uP4 (N=84). Unworn to slightly worn teeth were considered if at least their crown was preserved. µCT image data were obtained at the Vienna µCT-lab, Vienna, Austria. A total of 72 landmark points, including four landmarks and 20 curve semi-landmarks on the EDJ, 24 pseudo-landmarks each for the cervical and crown outlines, were collected. Afterwards they were analyzed by means of traditional geometric morphometric approaches [3].

Considering the entire uP3 and uP4 dentinal crown, our Principal Components Analysis (PCA) shows a clear grouping of the three taxa. *Pongo* and *Pan* are morphologically completely distinct while *Gorilla* is intermediate with some overlaps to *Pan*. The relative position of the horn tips varies, being more central in *Pan*. The distal fossa is more expanded in *Pan* than in *Pongo*, with a shorter distal wall in respect to the mesial wall. In *Pongo*, mesial and distal walls are of comparable heights.

The Two-Block Partial Least-Squares analysis demonstrates the high correlation between both premolars in all three taxa (r=0.84) which is comparable to the correlation found in human upper premolars (r=0.83) [4]). uP3s and uP4s covary strongly in the relative height and expansion of the distal aspect, and in the relative position and height of the dentine horns. Allometry is higher in the larger great apes than in humans. The effect of size on shape in *P. pygmaeus* is 9.3% in uP3s and 14.5% in uP4s. The greatest influence of size on shape was found in *G. gorilla* (27.0% in uP3s, 13.1% in uP4s). Instead, in *P. troglodytes* allometric variation is similar to humans (< 5.5%) [4]. Tooth size is significantly different (Kruskal-Wallis $p < 0.01$) between the three genera, with *G. gorilla* possessing the largest and *P. troglodytes* having the smallest premolars. This confirms previous findings using 2D measurements [2]. We found crenulations on the OES and bifurcation of the paracone horn tips in *Pan* and *Pongo*, occlusal tubercles (especially in uP4s) and a cingulum-like structure in *Pan* only, mostly present on the buccal aspect. Small hypocones and metacones were found in all three taxa.

In conclusion, uP3 and uP4 crown size differs markedly between the great ape genera but also shape separates them well. This is not surprising given the distinct phylogeny of African and Asian great apes. Our results further demonstrate that uP3 and uP4 shape correlation in great apes is high and very similar to that characterizing human premolars [4]. Findings for non-metric traits show a high variability in great ape premolars and deserve further investigation.

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A Proof of Concept for Machine Learning-Based Virtual Knapping

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Prehistoric stone tools are one of the earliest and most important forms of evidence for the study of human evolution. Hominins have made stone tools for at least 2.6 million years, and stone artefacts are an important line of evidence for the study of past human behaviour. To this end, archaeologists often rely on the experimental replication of prehistoric stone tools in order to understand the behavioural implications of shifts of hominin approaches to stone tool production. However, such experiments are time consuming and require large amounts of raw materials; thus, hindering the amount of possible able to be carried out, especially when exploring multiple interacting variables requires repeatedly performing these experiments. Computational models provide a potential avenue upon which to optimize this process. The ability to accurately simulate stone tool production would provide a means to more systematically explore the variables that influence stone tool production which may lead to insights on past behaviour or may inform replicative experiments. We present here the first results of a proof of concept for a machine-learning based 'Virtual Knapper': a framework for a computer program capable of quickly and accurately predicting the shapes of flake removals from 3D cores using neural networks. For this initial evaluation of the Virtual Knapper framework, we programmatically generated a dataset (N = 2010) of 3D cores and associated flakes as input to our model. These core and flake combinations were based on the Dibble glass experiments [1], though in some instances we removed multiple flakes from the same core. We converted the virtual cores and flake 3D models into 2D images that captured the surface information of both models based on a standard orientation—centred around the point of percussion of each flake and core set during data generation. We split these images into two sets: 70% for training the neural network, and the remaining 30% was reserved for holdout testing of the resulting Virtual Knapper. We trained the model to predict the resulting flake shape from the image of the unmodified core alone. After training, our model was evaluated against our testing dataset (30%; n = 603). The model proved able to accurately predict the resulting flake shapes. Outputs correlated well with the testing dataset flakes' length ($R^2 = 0.85$), volume ($R^2 = 0.76$), width ($R^2 = 0.64$), and overall shape (RMSE = 0.042, MAE = 0.027, interval = [0, 1]). As additional robusticity tests for the model, we evaluated performance under different training dataset sizes: 10%, 30%, and 50% of the entire dataset (the remainder of each split was left for testing), and found the model remained reasonably accurate even with fewer input (e.g. worst length prediction: $R^2 = 0.68$ for split = 10%, n = 1809). We also performed a replicability test by performing the training and testing independently on a different workstation, obtaining highly comparable results. We conclude that our Virtual Knapper model, using our computer-generated flakes, was successful in predicting the shape of flake removals from the unmodified core surfaces alone. In addition, the model appears to be robust to so-called 'overfitting', and provides reasonably accurate predictions even with a very limited dataset. We plan to extend this approach to real life data, using 3D scans of real cores and flakes to test the model's accuracy with a larger, more variable, and more externally-valid dataset. If successful, we would have a framework for widespread, fast, and cost-effective virtual lithic experimentation. Such a program could be used to explore the variables that affect stone tool production through repeated virtual lithic experimentation, which could have important implications for our understanding of the evolution of hominin behaviour.

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Understanding the Stone Age economics of heat treated silcrete

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Fire's use to systematically manipulate the natural properties of rocks was a key Stone Age behavioral innovation [1]. South Africa's Middle Stone Age (MSA) record has in recent years attracted the attention of researchers because of its rich evidence for silcrete heat treatment [2]. The proposal that heating silcrete and other rocks makes them more suitable for stone tool production is not new [3]. However, there is relatively little empirical evidence actually linking specific heating strategies to improvements in stone tool-making and use.

Our current experiment addresses these gaps and answers the following questions: do variations in silcrete heat treatment strategies affect flaking outcomes and the quality of flakes? We address these questions in a series of silcrete heat-treatment and knapping experiments designed to test a series of straightforward null and alternative hypotheses examining the relationship between variations in silcrete heat-treatment and lithic flaking and functional properties [4,5].

This experiment used one large silcrete block, weighing approximately 30 kg, collected from an outcrop near Diepkloof rockshelter in South Africa. One of these nodules was kept as an unheated control and two were heated to different temperatures using two different wood types in an embers-cone heating condition. The remaining two nodules were used in a second experiment in which we placed them onto the embers of a surface fire to approximate a minimal investment silcrete heating strategy.

Following the heat-treatment, each silcrete nodule was broken into several sub-nodules to facilitate knapping. The knapping experiment's overall goal was to reduce the sub-nodules until accidents (step and hinge fractures, obtuse flake angles) were insurmountable.

We used several variables to track core reduction intensity and flake utility. After the knapping experiments, we investigated the sharpness of unheated and heated flake edges using an Instron 3345 universal testing machine and a standardized hafting protocol (Key et al., Under review). The cutting test flakes were sent to AK, who was kept 'blind' as to the heating conditions for each flake type.

Quantitative comparisons show heat-treated silcrete produced significantly smaller flakes, more acute cutting edges, and a higher amount of flake cutting edge to mass. The method of heat treatment had no significant effect on flake size or quality. Comparisons of core size and utility show significant differences between heated and unheated nodules, and no significant differences between different heating conditions. The unheated nodules proved to be tough and difficult to flake. The poor knapping quality of unheated silcrete significantly impeded efforts to continue flake production. In contrast, both the heat-treated nodules showed marked improvement in knappability over the un-heated samples.

The flake sharpness tests show that when flakes are fresh and at their sharpest, heat treated silcrete flakes require roughly half as much force and about one third of the energy to cut compared with unheated silcrete flakes; these flakes also displaced the PVC pipe significantly less. Silcrete heated in the embers cone condition are significantly sharper and require less force and energy to cut than flakes made in the surface fire condition.

It is reasonable to hypothesize that Stone Age populations would have actively sought reductions in energy and force expenditure during stone tool use. Our results demonstrate that individuals concerned with such factors in the southern African MSA would therefore have benefited from the use of heat-treated silcrete. When the necessity of fire for heating, cooking, and safety are also considered, there was likely little energetic cost to engineering stone in this way, but (and as demonstrated here) substantial benefit. Together, these selective pressures could have provided a strong mechanism favoring the widespread use of heat treated stone.

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Archaeological signatures of chimpanzee perishable technology reveal the behaviour of the tool-makers

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Selection and transport of materials for tools is ubiquitous throughout our evolutionary history. Yet, our perception of the evolutionary trajectories of human material culture is heavily skewed towards lithic technology – because stones are more durable, but also, because we know little about archaeological signatures that plant-based artefacts may leave in the environment. Indeed, while the first tool-kits almost certainly contained plant-based artefacts, these are absent from the record until 300,000 years-ago. This poses challenges when reconstructing our technological origins, as prevalence of plant tools in modern hunter-gatherers and non-human primates suggests that current archaeological data is missing a substantial component of ancient technology. To learn more about plant-based implements of early humans, we can, as a proxy, study their use by extant non-human apes. Employing archaeological methods, we investigated raw material sourcing for termite-fishing tools by three chimpanzee communities in Tanzania. We found that the extraction of raw materials for termite-fishing tools creates damage on the plant surface that can provide rich information about past behaviour. Use-wear marks on a total of 307 plant sources from the vicinity of 29 *Macrotermes* mounds were quantified for populations in western Tanzania (Gombe, Issa and Mahale). All communities selected plant sources from the immediate vicinity of termite mounds, as well as further away, and reused them. However, at Issa, more parts were sourced per plant, with number of removals decreasing as distance from the mound increased. These disparities are likely caused by environmental differences – Issa apes might try to keep transport costs low in what is a comparably more open and drier habitat, with less suitable sources available near mounds. Despite similar raw material types available at all sites, Issa and Mahale chimpanzees exclusively used bark for tool manufacture, while at Gombe various materials were employed – differences that potentially reflect cultural variants. Our study highlights how environmental and cultural factors shape chimpanzee technology, and identifies similarities with raw material selection processes described in Oldowan technological behaviours. Though still in its infancy, the 'archaeology of the perishable' opens up new insights into a commonly overlooked aspect of the evolution of human technology.

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At the cross-road of Mediterranean Europe. The human peopling of the Great Adriatic-Po Region during the Last Glacial Maximum

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Since the time of the Middle Pleistocene Revolution, the increased magnitude of glacial cycles and unstable climatic conditions deeply influenced human environment adaptive strategies and lifestyle. This occurred also during the Upper Palaeolithic, when hunter-gatherers experienced dramatic turnovers, as attested by discontinuous biological and archaeological records [1, 2]. The timing and pattern of multiscalar shifts that occurred from the Last Glacial Maximum (LGM; 30-16.5 ka sensu [3]) to the onset of the Late Glacial (LG) interstadial are considered to be among the most important events. This period was characterized by large-scale climatic oscillations triggered by changes in insolation degree that led to the build-up of boreal ice sheets and emersion of major continental shelves along the coast of North, Southwest and South Europe as a consequence of the lowering of sea level up to -120 m a.s.l. [3]. Human groups reacted to ecological turnovers by increasing their resilience, as shown by a large array of evidence revealed by sites persisting at middle latitudes. Anyhow, also large migrations took place through the corridors connecting European and Mediterranean regions, and pronounced changes in demography and behaviour occurred, resulting in the synchronic and diachronic development of a variety of archaeological cultures in different regions and at different times [1]. Lastly, these events deeply contributed to shaping our present genetic ancestry [4]. In Mediterranean Europe, the combination of the sea-level dropping with the extension of alpine glaciers contributed to the aggradation of the Great Po Plain (GPP) in the Great Adriatic-Po Region (GAPR). The GPP is largely known as the largest alluvial plain ever existed which connected the Italian and Balkan Peninsulae. Geomorphological, sedimentological and ecological processes led to the persistence of boreal forests in moist habitats on stable areas and wetland margins, while open woodlands, steppes and semideserts occupied the uplands and part of the plain, where tree cover persisted until the LG. This offered suitable environmental conditions for several mammal species, while large part of their former distribution range, in Central and Northern Europe, was covered by ice sheets. South of the Alps, the more favourable environmental conditions also allowed the survival and delayed extinction of important consumers like cave bears. The presence of a rich mammal fauna in this southern glacial refugia provided subsistence to hunters-gatherers groups and enhanced their capability to maintain large-scale networks. Gravettian and Epigravettian hunter-gatherer groups inhabited the GPP, although their presence and settlement dynamics at the margins and across this region have raised questions for decades. Actually, a handful of archaeological sites outlines a patchy record of the peopling of the plain itself. Nonetheless, evidence of contacts across this area is provided by the exploitation of common chert sources and by stylistic and technical similarities in the lithic industries documented in northern and central-eastern Italy, Slovenia, Istria, and Dalmatia. Thanks to its peculiar geographic setting and climatic and ecological variability, GAPR is supposed to have represented a paradigmatic case which supported vast movements of populations [5]. Settlement dynamics, mobility, subsistence and symbolic thought as reflected by multidisciplinary data are here reviewed to assess the role of human adaptive flexibility and population turnover as recorded by genetic discontinuity (Fu et al., 2016). As an alternative the possibility of a concurrence of both factors in drawing distinct biological and cultural ancestries is also explored.

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Sex ratio in the Baka Pygmies

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Several external factors seem to influence the sex of new-borns. Although the biological mechanisms of transmission of external conditions to the regulation of sex during pregnancy are not known, it is thought that the sex ratio (SR) is in relation to the general state of the mother, particularly with her fertility and the caloric intake; the latter probably also influencing the first. Indeed, in population with low fertility rate the number of new-born males show a tendency to increase (positive SR) [1] whereas mothers living in unfavourable conditions seem to have more new-born females (negative SR) [2]. Forager societies are more subject to environmental conditions, so the study of SR in these societies can allow a better understanding of the relationship between environmental conditions and SR. We have analyzed the SR in the Baka Pygmies from Moange le Bosquet, a population in south-east Cameroon. Birth records had been kept for many years in Moange le Bosquet by nuns in a medical center of the catholic mission. They are available from 1980 to 1983 and from December 1987 until the present. The quality of the data allows to follow the SR during almost forty years and it enable to assess whether the SR changes through years, and also within the year in relation to the weather seasons and economic activities. SR in the Baka for all these years is 1.04 which is close to the average world value (1.07). When it is compare with other forager populations, the SR is lower than in the Ache (1.16), the Aka (1.22) and the !Kung (1.20) but is close to other Pygmy groups who live in similar environmental conditions, the Aka (1.09) and the Efe (1.09) [3]. Regarding long term variations, the SR varies from one year to the other, but it is interesting to note that during the last twelve years the SR becomes male-biased with three peaks of 1.5 and in only two years the SR was less than 1. We have reported that fertility in the Baka is falling down since 2010 [4]. Thus, a male-biased SR during the last period could be related to this drop in fertility. When SR is analysed after the month, a peak of male birth is observed between August and October with a SR higher than 1.4. Assuming the presence of relationships between environmental conditions and SR, it is interesting to note that the period of conception related to this strong bias toward positive SR is the month December-February which correspond to the dry season when fishing, a women activity, becomes an important contribution in the Baka economy.

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Deciphering the feeding ecology of *Dolichopithecus*: Insights from Dental Microwear Textural Analysis and Dental Topography

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During Plio-Pleistocene times Cercopithecidae demonstrated a rapid increase in their taxonomic diversity both in Africa and Eurasia. This is usually correlated with their ecological diversity as a response to a complex sequence of global and/or regional climatic events. *Dolichopithecus* is a large Plio-Pleistocene colobine that inhabited Eurasia. The limited available evidence suggests a semi-terrestrial lifestyle. This contrasts with the extant African and Asian colobine monkeys which exhibit morphological and physiological adaptations towards arboreality and folivory, and raises further questions concerning early colobine ecology. Besides its Eurasian predecessor *Mesopithecus*, which also exhibited semi-terrestrial characters, there is scarce information regarding the ecology of fossil Eurasian cercopithecids. To address this issue, here we attempt to characterize the feeding ecology of *Dolichopithecus*. By doing this we aim to better understand the adaptive mechanisms used by cercopithecids to withstand environmental and selective pressures if/how this is correlated with their taxonomic and ecological diversity. Moreover, it is speculated that *Cercopithecidae* possibly coexisted with hominids during Plio-Pleistocene, at least in the African realm. Thus, decoding colobine and consequently cercopithecid paleoecology is also important to understand the nature and diversity of paleohabitats that human evolution took place.

Dental microwear analysis was applied on *Dolichopithecus* specimens (N=30, 52 facets) from fossiliferous localities of France, Greece, Bulgaria and Romania, in order to explore its feeding behavior prior to death. The dental capabilities and potential dietary adaptations were then assessed through dental topographic analysis on an upper first molar of *Dolichopithecus ruscinensis* from the type locality of Perpignan, France. We used a set of African and Asian extant cercopithecids with known dietary habits for comparisons.

Dental topographic analysis suggests that *Dolichopithecus* had a versatile morphology capable of efficiently processing a wide range of food resources. Also, results of the microwear analysis suggest that its diet ranged from folivory to hard food consumption. This suggests a more opportunistic feeding behavior which supports the hypothesis of a semi-terrestrial lifestyle.

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The Boxgrove Horse Butchery Site In Context: Detailed Site Taphonomy and Landscape Scale Interpretation of Middle Pleistocene Hominin Behaviour

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The open-air site of Boxgrove (ca. 480 ka) is one of the most important sites for understanding the European Acheulean technology (Roberts and Parfitt 1999), due to the extraordinary preservation of the lithic assemblage that allows analyzing shaping strategies and handaxes morphological variability (Pope, 2002; Emery, 2006; García-Medrano et al., 2019). The sequence of Boxgrove is composed by a sequence of Middle Pleistocene marine, freshwater and terrestrial sediments exposed in the former Eartham Quarry, West Sussex, UK (Barnes, 1980; Roberts and Pope, 2009, 2018).

Earlier this year one locality at Boxgrove, The Boxgrove Horse Butchery Site (GTP17), was published (Pope et al. 2020). The site allowed for the reconstruction of activities including biface manufacture, defleshing of bones, marrow extraction and the production of bone tools. Detailed analysis of site formation processes suggest the entire episode possibly occurred within a single day, with the scatters of flint and bone sealed quickly within fine intertidal silts. These silts not only preserved the spatial integrity of the activity at the site, but also sealed a record allowing behaviour of an entire hominin group, including social interactions, to be brought under direct study.

In this paper we take the analysis of site formation processes of stone artefacts further, both applying and testing the interpretation through inferential stats and analysis tools based on GIS to determine localised differences in preservation. We compare the signatures from the Horse Butchery Site here to the longer term, and later accumulations recorded at the Boxgrove waterhole site and begin to test the initial taphonomic interpretations of that locale (Pope 2002). The comparison is used to highlight how the entire palaeolandscape, preserving a range of signatures from short term 'in situ snapshots' to longer term palimpsest accumulations might be integrated into a single model hominin behaviour for full, 26km wide, extent of the palaeolandscape.

This work is based on data from the UCL Institute of Archaeology Boxgrove Project excavations. The artefacts are currently accessioned at the British Museum.

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Carrying for free? Testing the human capability of load transport without added costs

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Carrying loads is an essential human behavior [1]. Several researches propose that humans have extremely efficient carrying methods, without incurring any extra locomotion costs, named "Free Ride Hypothesis" [2]. Nonetheless, recent investigations do not agree with this assumption [3].

Due to the relevance of carrying behaviors for human ecology, the aim of this research is to evaluate the "Free Ride" capacity on a sample of 48 adult individuals (21 females and 27 males). The energy expenditure of these volunteers was recorded by Indirect calorimetry at resting (Resting Metabolic Rate -RMR) for 30 minutes, and during locomotion tests without loads and while carrying 5, 10 and 15 kg backpacks. The locomotion trials lasted for 10 minutes, with 5 minutes to rest between them. These experimental tests were carried out at the Bioenergy Laboratory of the National Research Center on Human Evolution (CENIEH, Burgos, Spain), under the project led by Dr. A. Mateos, with the approval of the Hospital Universitario de Burgos Ethical Committee (Ref. CEIC 1480).

The net energy expenditure of locomotion trials was calculated extracting the cost of RMR from the gross cost of the tests, in mililitres of oxygen (mlO2). The absolute loads carried were transformed to Relative Carried Loads (RCL), as a percentage of volunteers' body mass. Then, the percentage of the increment in the net cost (Increment Net Cost (%)) of the load trials over the unloaded one was assessed. T-tests were used to compare gross and net costs of burden locomotion trials with the cost of the unloaded locomotion trial. Finally, a simple correlation was computed with the RCL and the Increment Net Cost to observe the relationship between the percentage of body mass represented by the loads carried and the percentage of the increment in the net cost of the carrying trials. This simple correlation was performed considering alternative models, to test if the relationship between the variables fit better on a nonlinear model.

The results show that, although burden trials present higher values of energy expenditure, only the heaviest loads (10 and 15 kg) increase significantly the energy costs over unloaded locomotion. When the RCL is plotted against the Increment Net Cost (%), the best fit is obtained with a quadratic model, not with a linear model. This indicates that the costs of locomotion do not increase in all the individuals in a direct proportion to the burden carried. Hence, it can be observed that the load carriage costs remain stable for loads representing less than 20% of the volunteer's body mass. So, in general terms, we cannot conclude that the volunteers of our sample have the capacity to transport several loads without added cost to locomotion ("Free Ride"), agreeing with Lloyd et al. (2010) [3]. Thus, our results do not support the existence of a "free ride" in the participants of our sample, but we highlight that the energetic costs of locomotion are only significantly incremented when the heaviest loads are carried.

As it has been proposed elsewhere [4] carrying 5, 10 and 15 kg of food resources, covers in excess the energy expenditure of their transport, at least for 2 hours, over flat terrain at a constant speed of 4 km/h. However, the fact that humans have certain load transport energetic efficiency, makes sense when the burden transported does not represent a direct energetic benefit. Therefore, humans can transport loads at least up to 10 kg without a substantial increment over the cost of unloaded locomotion. This issue is relevant when the burdens are dependent children or raw materials. These are daily life behaviors among current hunter-gatherers [5] and are considered essential to understand human evolution.

We are sincerely grateful to all the volunteers who participated in this experimental study. Our research was performed at the CENIEH facility Bioenergy Laboratory. Data were obtained from the EVOBREATH DataBase, managed by A. Mateos and J. Rodríguez, currently available in the online dataset of Mendeley Data (Mateos, 2020). Zorrilla-Revilla is beneficiary from predoctoral research grant EDU/602/2016 from Junta de Castilla y León funded with the Social European Fund, Operative Program of Junta de Castilla y León, through the Consejería de Educación.

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Cortical bone distribution in the femoral diaphysis and its relationship to activity level

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The distribution of cortical bone in long bone cross-sections is used to infer physical activity in fossil hominins and archaeological populations. During life, habitual loadings reshape the morphology of the diaphysis as it adapts to stresses induced by normal daily activity [1-2]. However, the distribution of cortical bone is also influenced by genetics, body size and environmental factors. Here, we report preliminary results from an investigation of femoral diaphyseal variations in shape and cortical bone distribution in archaeological populations characterized by different activity levels (ALs). We tested the hypotheses that diaphyseal shape and cortical bone distribution are unrelated to activity levels. Diaphyseal shape is assessed using semilandmarks on the periosteal and endosteal surfaces of femoral cross-sections and cortical bone distribution is assessed in relation to biomechanically relevant measures of cross-sectional geometry (CSG). Activity levels were scored from archaeological and ethnographic data. We analysed 65 femora belonging to different populations characterized by different lifestyles and therefore habitual loadings: i) an Iron Age group from Alfedena (Italy), ii) a Middle Bronze Age group from Olmo di Nogara (Italy), iii) a recently extinct hunter gatherer group from Tierra del Fuego (Argentina) iv) a group from the Lombard necropolis of Selvicciola (Italy), v) an urban population from Opava-Pivovar (Czech Republic) and vi) a group from the Eneolithic-Bronze Age of the Czech Republic. We applied the *morphomap* R tool [3] to acquire 5 cross-sections from each femur along the diaphysis from 20% - 80% of biomechanical length. On each cross-section we defined a total of 24 equiangular semilandmarks on the periosteal and endosteal outlines and derived common biomechanical parameters of CSG. Additionally, the semilandmark configurations on the periosteal and endosteal surfaces were submitted separately and together to generalised Procrustes analyses (GPA) and principal components analyses (PCA) to assess shape variation among populations. Using 2 block partial least squares (PLS), we assessed the associations between femoral outline shapes, CSG parameters and ALs. Principal component analysis of shape shows that populations are moderately separated with considerable overlap. The Fuegians are the most distinctive in showing a medullary canal that is antero-posteriorly flattened proximally. Periosteal surface shape more strongly correlates with CSG than endosteal ($r=0.87$, $p<0.0001$ vs $r=0.43$, $p=0.046$) and is also more strongly associated with ALs than the endosteal surface in PLS analyses ($r=0.62$, $p<0.0001$ vs. $r=0.45$, $p=0.041$). However the CSG parameters show significant association with ALs, only when Fuegians are excluded from the analysis ($r=0.31$, $p=0.03$). The findings indicate that periosteal femoral diaphyseal shape is more associated with ALs than endosteal and that CSG parameters appear to be relatively less associated with ALs, which is problematic given that they are often calculated for this purpose. However, this may be because our scoring of ALs is inadequate to capture the full range of possible loadings generated by different lifestyles. For instance, including the Fuegians in the assessment of association between CSG and ALs produces a non-significant result. This may be because while they are scored by us as having high activity level, by virtue of being hunter gatherers, in fact they habitually engage in fishing and canoeing which may complicate such categorization [4]. In conclusion, these preliminary results falsify the hypotheses: diaphyseal shape and cortical bone distribution have a relationship with population activity levels. Future work will focus on increasing the sensitivity of these approaches before applying them to a larger sample and comparing their efficacy with that of finite elements analysis in retrodiction of habitual loading in hominins.

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Peer Community In Archaeology - A new system for peer-reviewing of preprints

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The number of scientific articles has increased dramatically and should continue to grow in the coming years. However, the current system, managed by a few for-profit publishers, has become very costly for our institutions. The deposit of preprints in open archives, such as OSF, Zenodo, or bioRxiv, is a solution for rapid dissemination, but the quality of these preprints must be guaranteed. The dissemination of science is evolving rapidly with the widespread use of social networks. The traditional model of publishing in paid journals is increasingly being criticized. Calls for the re-appropriation of the system by researchers have multiplied in recent years. This is why Peer Community In Archaeology (PCI Archaeology) was created: to enable our community of researchers to assess the quality of the work deposited in open archives and thus ensure broad dissemination of high-quality science. In this context, PCI offers, in an innovative and realistic way, a new way to communicate our scientific results: free for authors and readers, open, online. Therefore, the PCI initiative, and in particular this one dedicated to archaeology l.s. promotes a system of scientific dissemination that is cheaper and more effective. PCI Archaeology also supports Open Science and scientific reproducibility by making mandatory the deposit of all necessary datasets prior to the recommendation of any preprint and by providing the possibility of pre-registration papers. The process is as follow: the authors deposit the preprint on an open archive, then ask the PCI Archaeology community for a recommendation. The recommendation, handled by a recommender, is based on classic peer-reviewing by at least two referees. The peer-review, the decision, the answer of the author, are published on the PCI website, while the preprint remains on the open archive. This recommendation does not prevent from publishing the manuscript in a traditional journal, even if it is already at this point confirmed as a quality article and thus trustable and citable. More than 60 archaeologists covering all fields of archaeology are already supporting the project, and can handle the submitted preprints as associate editors would do in a traditional journal. We are waiting for your best research !

The utility of different dental traits and trait combinations for inferring human population history

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Dental remains are an important data source for archaeological and paleontological studies because they are generally well preserved in taphonomic contexts, even when associated skeletal and DNA preservation is poor. Furthermore, tooth morphology is highly diverse and varies among individuals and populations and is considered to be heritable and selectively neutral, thus, providing an excellent proxy for DNA when none is available. As a result, dental morphology is widely used for inferring population histories and hominin phylogenies. Dental morphology is routinely characterized using non-metric traits by reference to standardized scoring protocols such as the Arizona State University Dental Anthropology System (ASUDAS) [1]. The ASUDAS catalogs a large number of crown and root shape variants for the permanent adult dentition, which have been found to be differentially expressed across human populations worldwide. However, until today it remains poorly understood whether certain dental traits or trait combinations preserve neutral genomic signatures to a greater degree than others. We addressed this research gap by systematically testing the utility of 27 ASUDAS traits and all 134,217,700 possible combinations of these traits in reflecting neutral genomic variation at 645 microsatellite loci [2]. To assess the utility of a given trait or trait combination, we estimated dental phenotypic distances (D_P) between 20 worldwide modern human populations, and compared them to neutral genomic distances (D_G) among the same, or closely matched, populations. The congruence between D_P and D_G was quantified by linear regression using Pearson's correlation coefficient (r). To account for stochastic variation inherent to a neutral model of evolution, we calculated r for a given dental trait or trait combination 1,000 times, each time comparing D_P to different D_G randomized by subsampling genomic loci. We then calculated the median of the resulting distribution of r values as the utility estimator for a given trait or trait combination ($\tilde{x}_r$) and constructed a 95% inter-percentile range to measure the spread of r values around $\tilde{x}_r$. Our results reveal that not all dental traits are equally well-suited for inferring neutral genetic affinities across populations. Whereas some traits reflect neutral variation and therefore evolved primarily as a result of genetic drift, others can be linked to non-stochastic processes such as natural selection or hominin admixture.

As a rule of thumb, dental inferences about neutral genetic affinities based on many traits are more reliable than those based on only a few traits. Nevertheless, the best performance is achieved when using specific combinations of highly diagnostic traits ($\tilde{x}_r$ = 0.580; 95% r range = 0.293 to 0.758; p = 0.001), and not the full trait set ($\tilde{x}r$= 0.428; 95% r range = 0.146 to 0.688; p = 0.001). The highly diagnostic trait combinations found in our study consist of batteries ranging from 14 to 20 traits and always comprise the following five traits: mesial ridge (UC), distal accessory ridge (UC), protostylid (LM1), lingual cusp number (LP2), and cusp 6 (LM1). The combinatorial power of these traits can be explained by the fact that together they reflect major components of phenotypic structure at a global level. The addition of other dental traits serves to capture more subtle variation at lower geographic scales. We propose that these trait combinations should be prioritized in future research, as they allow for more accurate inferences about past population dynamics when using dental morphology as a proxy for DNA. Finally, we generated a reference table of $\tilde{x}_r$ utility estimates for all traits and possible trait combinations that can be used to validate the performance of a particular trait combination employed in previous and future studies. We anticipate that our study will serve as an important reference for a wide range of future dental morphological investigations.

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Why foraging ecology matters for understanding the origin of culture in the Oldowan archaeological record: Insights from Kanjera South

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The aspects of hominin behavior responsible for Oldowan stone tool variation has been the focus of much debate [1]. While there is a consensus that Oldowan tool variation arises from a combination of ecological and cultural factors, these factors are often examined independently of one another [2]. While documentation of various technological strategies is often used to draw social and cognitive inferences regarding Oldowan tool makers, the influence of environmental factors such as raw material provenance on Oldowan technology has seldom been examined. The diversity of raw material types and technological strategies present at the site of Kanjera South provide an opportunity to examine the interacting effect of ecology and culture on Oldowan stone tool variation [3] [4]. This study investigates the influence of environmental factors on the technological strategies applied to the lithic assemblage at Kanjera South. In doing so, estimate core reduction intensity using quantitative measures of lithic attributes. These estimates are then combined with previous analyses of raw material properties, provenience, and technology to establish relationships between environmental factors and lithic production strategies.

The results of this analysis show that raw material provenance has a significant influence on the level of core reduction intensity and the representation of core reduction strategies. Cores produced on materials that are acquired from more distant sources are more reduced than those that are more locally sourced. Consequently, core reduction strategies that involve more rotation (i.e. bifacial, multifacial) are on average more reduced than unifacially reduced cores. Raw material properties influence core reduction strategies, these results suggest that bifacial and multi-facial reduction strategies may also arise due to the long-distance transport of cores. These results demonstrate that ecological factors such as raw material provenience and physical properties have strong impacts on reduction intensity and the technological strategies utilized by hominins. Therefore, Oldowan stone tool variation should not be examined from a strictly ecological or technological perspective, but rather within the context of its cultural-ecological system. The broader implications of these results for understanding the behavioral mechanisms underlying Oldowan stone tool variation are discussed within a broader evolutionary context.

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Footprints of Fire: fundamental research into the effect of diagenesis on heated bone and its implications for the study of fire use in the deep past

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The use of fire is considered to be one of the most important cultural innovations in human evolution. Gaining insight into when and where our ancestors first started using fire, and what they used it for, therefore has important implications for our understanding of key aspects of early human lifeways. Fire use is often identified based on the presence of organic and inorganic thermally altered materials, such as charred plant material, heated bone, ash, and heated sediment and lithics. Presence/absence data is used to infer varying degrees of hominin control of fire [1], while the properties of fire proxies are analysed to infer heating conditions and specific aspects of fire use [2]. As preservation is a major factor in the availability and visibility of fire remains in the archaeological record, understanding the taphonomy of fire remains is an important prerequisite for valid interpretations of hominin fire-related behaviour. This presentation showcases the results of extensive laboratory-based experimental research into the effect of pH on the physical and chemical properties of heated bone. Bone samples heated to different temperatures (20-900 °C) and exposed to different oxygen levels (charred vs. combusted) were incubated in pH solutions representing acidic, neutral, and alkaline conditions. Subsequently, samples were analysed with a variety of analytical techniques, including TGA, XRF, XRD, FTIR, and py-GCMS, and results were compared to reference data derived from unexposed heated bone [3, 4]. The study indicates that the tested pH conditions each have a different effect on both the charred and combusted bone, resulting in colour change, mass loss, and fragmentation. Changes also occur in the molecular signature and crystallinity of both types of bone. pH thus not only affects the preservation potential of heated bone, but also the reliability of the chemical properties used to reconstruct past heating conditions. These findings have important implications for the way we reconstruct past fire use. The feasibility of an integrated approach combining this new pH data with existing reference data on heated bone (and other fire proxies) was successfully tested on the combustion features at the Upper Palaeolithic site of Abri Pataud (Les-Eyzies-de-Tayac, France) (Braadbaart, Reidsma et al., under review). In this study diagenesis was explicitly accounted for, allowing for more accurate reconstruction of the heating conditions and a more refined view of fire-related human behaviour at the site.

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Virtual cranial reconstruction and paleopathological reanalysis of an Early Iron Age skeleton from Frankfurt/Main

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One of Germany's most important prehistoric finds from the Early Iron Age is a chieftain burial from Frankfurt am Main. The Early Iron Age chieftain from Frankfurt was excavated in 1966/67 and represents a remarkable discovery. An almost complete skeleton together with grave goods was found in an undisturbed burial mound. The skeletal remains are fragile but allowed for an age estimation of around 50 years at death, while the sex was estimated as male [1], [2]. The archaeological material was dated to around 700 BCE and thereby, about 170 years older than the grave of the »Chieftain of Hochdorf« [3] and 250 years older than the grave of the »Chieftain of Glauberg« [4], [5]. Consequently, it is one of the oldest known burials of the Early Iron Age elite in central Europe.

Here, we present a new reconstruction of the fragmented cranium of the chieftain based on virtual anthropological methods. Prior to the reconstruction, each fragment was segmented separately to allow independent movement. The cranium was manually reconstructed based on bilateral symmetry and smooth curvature. When the position of fragments had to be corrected in order to deal with taphonomic distortion, smoothness was prioritized over bilateral symmetry. The preserved anatomical features cover almost the entire cranial anatomy and a manual reconstruction would be sufficient for standard osteological analyses. However, as the virtual reconstruction will be used in a museum context, further reconstruction was deemed necessary in order to enable 3D printing and ultimately to make the final reconstruction more accessible to museum visitors. Retaining gaps between preserved fragments were closed via geometric warping of a reference cranium onto the manual reconstruction of the Iron Age chieftain based on a 3-dimensional landmark set.

Furthermore, a study of bilateral asymmetry was carried out on the manually reconstructed cranium (only containing the preserved fragments), the 2nd cervical vertebra, and the humeri, in order to explore the possible impact of a healed trauma in the left clavicle on the other skeletal elements. The new virtual cranial reconstruction allowed the analysis of several cranial features as well as muscle attachments, linking cranium and postcranium. Bilateral cranial linear measurements and surface distance maps between bones and their bilateral counterparts suggest only slight to moderate restrictions in the range of motion caused by the healed trauma.

All in all, the Early Iron Age chieftain from Frankfurt is an example for the combination of virtual methodologies often used in (paleo-) anthropological research and public outreach. Osteological evidence provides a scientifically valuable snapshot in time of a socially outstanding male individual which highlights the existence of a social order in the Early Iron Age setting it apart from egalitarian systems like hunter-gatherers. In addition, the 3D print as well as an interactive part within the exhibition will make the Early Iron Age chieftan as well as the time period more accessible to the museum visitors.

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Delayed acquisition of adult feeding behaviour in the great apes – Implications for inferring the dietary niche of fossil hominins

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Diet is a central factor in an animal's biological adaptation. During our evolutionary history hominins underwent major dietary shifts from an essentially frugivorous ancestor to an eclectic omnivore who habitually consumed animal matter; the consequences of these changes for brain evolution, cognition and life history strategies were profound. Subtle differences in dietary adaptations even allowed early hominins to successfully co-exist, e.g. early *Homo* and *Paranthropus*. Hence, determining the dietary habits of extinct hominins has been a major focus of palaeoanthropological studies, whereby results of stable isotope analyses of hominin hard tissue [1] and microwear texture analyses [2] are considered most informative. Analyses of permanent molars are at the heart of such investigations.

The eruption of first permanent molars (M1) marks the beginning of the juvenile period, the animal's independence from its mother and the switch to an adult diet. However, in hominoids the co-occurrence of these events may not be as tight as commonly assumed [3]. If confirmed, this would compound insights derived from analyses of M1s for an appraisal of species-specific adult diets in extinct hominins. To investigate this possibility, here we analyse maturity-related lower M1 shape changes, using GIS-based slope, relief and angularity topographic metrics [4], in a cross-sectional ontogenetic series of wild-caught central African *Gorilla g. gorilla* (15 males, 17 females) and *Pan t. troglodytes* (25 males, 12 females); for 43 individuals $\delta^{13}C$ and $\delta^{15}N$ from hair of associated pelts are also available [5].

Uni- and multivariate statistics showed a significantly greater decrease in M1 shape descriptors with maturity in gorillas than in chimpanzees (ANCOVA: $p < 0.05$); no sexually dimorphic trend in M1 metrics was detected in either species. Whilst there is a consistent relationship between stable isotope changes with maturity and M1 shape changes, these trends reached statistical significance in *Gorilla* only. Conversely, we found $\delta^{15}N$ values (‰) to be statistically significantly, and positively, correlated with *Gorilla* M1 steepness from infancy to adulthood ($r > 0.5$; $p < 0.05$), suggestive of reliance on nutritional support from the mother despite M1 being substantially worn.

Our findings demonstrate that M1s develop their adult wear pattern only gradually. Moreover, isotope values for the same individuals suggest continued dependence on breast milk, even though first molars had been in functional occlusion for some time. This is perhaps unsurprising: the masticatory apparatus, including muscle mass, is not yet fully developed at this early stage of development and mastication of adult foods may therefore not yet be possible. Hence, ingestion of softer and more easily digestable foods (i.e., weaning foods) and of some breast milk is implicated. This observation has important consequences for palaeoanthropological enquiry however. For example, a recent microwear study of *Australopithecus africanus* and *Paranthropus robustus* used a sample that consisted of 20.5% and 27.3% M1s, respectively [2]. This likely biased the outcomes of their study, e.g. by increasing the dietary variability observed, and probably influenced the inferences drawn from these results. Based on the outcomes of the present study we caution against inclusion of M1s in studies that aim to determine the species-specific adult diets of extinct species, especially hominins, who have been on a trajectory of increased juvenile dependency during their evolutionary history.

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Modelling Late Pleistocene hominins in Western Europe

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The persistence of Neanderthals in Western Eurasia and their subsequent replacement or (partial) absorption by modern humans is viewed by many as one of the more intriguing enigmas of palaeoanthropology. Although intensely researched, many of the details remain unknown. To increase understanding of the Neanderthal way of life we implemented HomininSpace, a simulation system that utilizes archaeologically attested presence and absence data to validate modelling results of simulated dispersals into (sub)continental geographical areas and through archaeological time frames. HomininSpace implements an Agent Based Model with parameters from the demographic, social and subsistence domains. A range of hypotheses and combinations thereof can be tested in the system where plausible values for the model parameters are found using Genetic Algorithms, a technique borrowed from the artificial intelligence toolset to explore big datasets. With each simulation spanning 80k years and with the need for multiple simulations to generate sufficient data on the effects of each parameter, more than 3 billion years of simulated Neanderthal existence are processed in this research.

In HomininSpace variability in the environments of the Late Pleistocene is approached using reconstructed precipitation and temperature value series as well as calculated sea level changes. Hominin groups move through these landscapes in order to satisfy their energy needs for subsistence and reproduction. Parameter values in the model guide their movements. The whereabouts of these simulated groups is compared to archaeological distribution patterns, i.e. Neanderthals' radiometrically calculated presence in time and space (83 archaeological sites with 470 dated finds are used in the simulations). More matches with the archaeology suggest a better Neanderthal model. Between simulations model parameters are autonomously manipulated with a Genetic Algorithm in an attempt to generate more matches in the next simulation run. This specifically avoids researcher's biases about Neanderthal parameter values.

Due to the variability in the modelled environment, the large area and the long simulation period it becomes possible to address such research questions as the possible use of coastal resources, the ability to cross larger water bodies, the optimal size of foraging ranges or the most likely mobility strategy for Neanderthals. We find that the automatic parameter value optimization of the genetic algorithm is consistently capable of realizing well matched Neanderthal models that vary depending on the tested hypothesis. Each model has specific but different value combinations from within the multi-dimensional space of possible parameter values. In other words, the combination of model parameters from the different domains allows great flexibility in the way energy can be retrieved from the modelled landscape with differences depending on the imposed circumstances. The Neanderthal models evolved by the genetic algorithm significantly outperform those manually constructed by experts. Only when specific absence data is included in the measurement of success does the system fail to find good matches. The importance of these rather unexpected results is discussed.

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A bio-robotic solution to achieve targeted hand and foot placement in primate musculoskeletal simulation experiments

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One of the intriguing features of the limbs of primates is that they are often used for both locomotion and manipulation. The functional anatomy of these dual roles has received considerable attention, particularly in the context of the recent evolution of humans and the consequent changing roles of the forelimb with an increasingly emphasise on its manipulative role. Musculoskeletal modelling is a very effective technique for investigating the biomechanics of primate limbs, however, one of its limitations has been generating the appropriate muscle control required to reproduce experimentally observed actions. We have developed a novel system where we use an internalised muscle-length model such that any targeted movement of the hand or foot, as required for a specific manipulation or locomotor function, can be decomposed into the required length changes of the muscles involved, even when those muscles act over more than one joint and have different actions at different joint angles. This is combined with a series of user-defined heuristics such that we can choose between different possible joint configurations that achieve the same reach goal. Together this system enables us to generate length signals for each individual muscle that can then drive standard error-based controllers and allows faithful trajectory tracking with minimal deviation over large target volumes with physiologically realistic muscle contraction mechanics. In this poster we demonstrate this function using our full-body chimpanzee musculoskeletal simulation [1] as it tracks 3D moving targets with high precision. The technique is completely generalisable and would be effective for demonstrating limb function in any species where we can create a musculoskeletal model and appropriate target kinematics. Thus, in future it would be possible to simulate trajectory based tasks such as nut cracking, stone tool manufacture, or the targeted prehension required in climbing. The technique works equally well in both extant and extinct species which should allow us to objectively test specific hypotheses about the evolution of the functional roles of particular anatomical features, and the performance capabilities fossil primates.

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Developing a chronological and environmental framework of Early Pleistocene hominin expansions in the southern Caucasus: Current research in northern Armenia

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Understanding the timing and environmental context of the earliest hominin expansions into Eurasia is of considerable interest in palaeoanthropology, however our current knowledge is based on a handful of sites. Dated to 1.85–1.78 Ma, Dmanisi (southern Georgia) is not only the locus of the earliest Homo fossils in Eurasia, but has also yielded stone tools and rich assemblages of vertebrate fossils [1,2]. Whilst Dmanisi has fundamentally changed our views on the morphology of early Eurasian *Homo* and their technological capabilities, it represents a single site, and little is known about the broader regional environment.

The Debed river valley (located in the Lori Depression, northern Armenia) represents a key area in which to improve our understanding of this early hominin expansion. The area lies at the south east margins of the Javakheti Plateau, a large volcanic province spanning both southern Georgia and northern Armenia. Current chronological study of the Javakheti-derived lavas places the interval of volcanic activity between 2.1 and 1.6 Ma [3,4]. The lavas are exposed along the Debed river valley and trap sediment sequences below, within and atop the flows.

Here, we present the first results of our ongoing geoarchaeological investigations in the Debed valley. We present a model of landscape evolution during the Early Pleistocene based on detailed geologic and geomorphic mapping in the valley. We then describe preliminary results from two of the key sequences in the valley. First, we focus on preliminary results from combined chronological, stratigraphic, and archaeological study of the open-air site of Haghtanak 3. Here, the lower part of the sequence has yielded a Mode 1 artefact assemblage and rests atop a basaltic lava flow 40Ar/39Ar dated to 1.95 Ma. Second, we present the initial stratigraphic and chronological results from Dzoragyugh 1 palaeolake, a 30m thick fluvial-lacustrine sequence that is sandwiched between two basaltic lava flows 40Ar/39Ar dated to 2.07 Ma and 1.68 Ma. We discuss the environmental and archaeological significance of both sites, and place them in the context of Early Pleistocene landscape evolution in the Debed valley and wider Javakheti Plateau area. Through this, we highlight potential linkages between these sites and Dmanisi, located ~60km to the NW, and discuss the importance of northern Armenia for understanding the nature and environmental context of early hominin expansions into Eurasia.

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A preliminary survey on visual attention and stone tools

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Vision constitutes the dominant source of sensory information in humans and the primary input channel to the brain influencing our interaction with tools [1]. Vision itself is an active process that can be a proxy for the schemes and patterns underlying attention by providing information about what is being observed [2]. Attention may be influenced by visual features of an image that clearly stand out from the visual background due to their sensory properties (e.g., local discontinuities in colour, brightness, texture or orientation of the visual elements). Computational models of visual *salience* have been developed which can quantify the extent to which parts of an image are conspicuous and the distribution of gaze within an image has been shown to closely correlated with salience 'maps' generated by these models [3]. However, the intensions associated with an object might also influence the pattern of visual scanning in addition to its purely sensory properties. Such behavioural *affordances* may be considered as the behavioural possibilities of an object or the properties that indicate how to interact with it [4]. In the case of tools, affordances might be expected to automatically drive the eyes and visuospatial attention towards the parts of the tool most relevant to its action, such as the most comfortable grip position or the striking surface of the tool. In this study, individuals without archaeological knowledge were asked to visually explore different stone tool images, including examples of worked pebbles and handaxes, while we used eye tracking to monitor how they direct gaze and attention. We first analysed the tool images using a computational algorithm to determine which regions were visually salient and therefore should attract attention and eye movements accordingly [5]. Different areas of interest based on the main tool regions were defined, namely the top, the middle region and the base, as well as cortex and knapped surface. We measured the time of fixations for each stone tool (Dwell Time, measured in milliseconds) as an indirect measure of the amount of visuospatial attention allocated by participants to distinct characteristics of the visual scene. Our results suggest that knapped areas elicit more attention than cortex. As well, the middle region triggers more attention than the top, followed by the tool base. Finally, we compared fixation maps with the saliency maps of the same images, and both maps differ, suggesting that visual attention is influenced by specific tool's action affordances, associated with the morphology of these early stone tools. The aim of this study was examine the visual exploration of Lower Palaeolithic stone tools by modern humans in order to draw inferences with respect to the attentional and cognitive capacities of the extinct hominids associated with the making and use of these tools. The findings suggest that eye tracking can supply valuable information that inform brain-tool evolutionary relationships and offer support embodied cognitive perspectives on human cognitive evolution.

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Deciduous second molar morphological variation in the Baka pygmies, Cameroon

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The Baka pygmies are hunter-gatherers living in southeastern Cameroon. They diverged from the Bantu, a neighboring population, around 50-65,000 years ago after which they lived in almost perfect isolation until recently. Their short stature (<155 cm) is attributed to a deficiency of growth hormone-insulin-like growth factor I (GH-IGF I). While they show typical life history variables including the growth spurt during puberty, their growth is significantly retarded during the first two years of infancy, causing a long-lasting growth delay compared to non-pygmy populations [1]. In contrast, their posterior permanent dentition has been proven larger compared to neighboring non-pygmy populations. Moreover, the permanent dentition erupts earlier in the Baka than in any other African populations [2]. The 3D morphological variation of the Baka's teeth has never been studied before using geometric morphometric methods [3]. Given the peculiarities of this African pygmy population, including their particular population history, we investigated 13 Baka second upper and lower deciduous molars (dm2s) to explore possible morphological divergence from other modern human populations. The comparative sample consisted of 36 upper and 26 lower dm2s from Europe (n = 33), Egypt (n = 13), Southeast Asia and Oceania (n = 6), Near East (n = 6), and South America (n = 4). The 3D μCT scans of the Baka dm2s were obtained at the Plateforme Imageries du vivant, Université de Paris and Hard Tissue Research Unit, College of Dentistry (NYU); the rest of the sample was scanned at the Vienna micro-CT Lab. Five sets of landmark configurations were considered [4]: occlusal edge of the enamel-dentin junction (EDJ), cervical outline, crown outline, EDJ combined with the cervical outline, and combined cervical and crown outlines. Shape variation was assessed via principal component analysis, and upper and lower dm2s covariation via two-block partial least-squares analysis. The natural logarithm of Centroid Size was used for evaluation of size variation.

In all analyses, we found an extensive overlap of all populations. The lower dm2 crowns ranged from low and distally expanded to high and distally reduced. The Baka showed the broader range of variation for these aspects, also possessing the most mesio-distally elongated crowns. The upper dm2s varied mainly in the relative expansion and bucco-lingual position of the talon with respect to the trigon, and in terms of relative metacone expression. Upper and lower dm2 crowns showed high pairwise correlation (r1 = 0.82 for the combined dataset), varying from short and distally expanded, to high and distally reduced. The cervical outlines ranged from oval to hourglass-shaped (i.e., presenting a bucco-lingual constriction). As previously noticed for first permanent molars [5], the cervical outlines reflected different configurations of the roots, fused in the case of oval cervical outlines, or diverging (hourglass-like cervical outlines). South Americans and the Baka possess the largest dm2s while Europeans showed the smallest.

Despite Baka's long-lasting isolation, featuring only low levels of substantial admixture with non-pygmy populations and maintaining their unique growth pattern and eruption timing, no significant morphological differences were found suggesting any specific dm2 morphological or odontogenic patterns that could distinguish the Baka from other world populations. Notably, the range of morphological variation of the lower dm2s was larger than in other populations. In contrast to their short stature, the Baka also displayed relatively and absolutely large dm2s. A similar negative allometry was already observed for their permanent dentition.

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DNA from Paleolithic sediments at Sefunim Cave, Israel

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Genetic studies have been instrumental in shedding light on Middle and Upper Paleolithic populations, owing to the successful recovery of DNA from Neandertals, Denisovans and ancient modern humans in temperate regions of Europe and Asia. The warmer climate of the Levant, which degrades DNA more rapidly, has thus far impeded attempts to study the genomes of individuals of similar age there. To date, the oldest human DNA retrieved from the region originates from individuals dated to 12-14 thousand years ago (kya) [1].

As part of a larger study aimed at investigating the properties of DNA preservation in archaeological sediments throughout Eurasia, we collected 33 sediment samples from Sefunim Cave in Israel for genetic analyses. The samples were taken from freshly excavated areas, while taking precautions to minimize contamination introduced by handling, and spanned all five Paleolithic archaeological horizons of the site (AH VII-III) [2].

Following a previously-developed scheme to generate and analyze sequencing data from ancient sediments [3], DNA fragments were extracted from the samples and converted to DNA libraries. Prior to sequencing, all libraries underwent targeted enrichment for mammalian mitochondrial (mt) DNA in general, as well as specifically for human mtDNA. For each taxon identified in each sample, the mtDNA fragments retrieved were evaluated for the presence of nucleotide substitutions that tend to accumulate over time, in order to differentiate genuine ancient DNA fragments from present-day contamination. While none of the samples contained detectable traces of ancient human mtDNA, we retrieved ancient faunal mtDNA fragments from four samples. Two of the positive samples were collected from the Mousterian horizon (AH VII), consisting of few DNA fragments attributed to Cervidae and Hyaenidae mitochondrial genomes. The third sample, containing Cervidae mtDNA fragments, came from the horizon spanning the Middle to Upper Paleolithic transition (AH VI). Optically-Stimulated Luminescence dating for these two horizons is still pending, but current estimates place them between 45 and 70 kya. The fourth and richest sample originated from the horizon characterized by Levantine Aurignacian artefacts (AH V), dated by radiocarbon to between 30 and 40 kya [2]. This sample yielded sufficient DNA fragments to reconstruct ~1/4 of a likely-composite mitochondrial genome sequence, enabling us to place it within the variation of Cervidae mtDNA. We note that the identification of Cervidae and Hyaenidae DNA in the sediments is consistent with the archaeological record for these horizons, the former being represented by bones and antlers and the latter by bones and coprolites.

Intriguingly, all four samples were taken from the same area within the cave (Units G/H 48/49), suggesting that local conditions there were particularly conducive to the preservation of DNA over time. We hypothesize that a large boulder, which covered that area for millennia and which was removed shortly prior to sampling, helped to reduce the loss of DNA in the underlying sediment by limiting the acidity and biological activity within the sediment. The recovery of DNA from sediments at Sefunim Cave pushes back the current limit of DNA preservation in the Levant by more than 15,000 years. This demonstrates the feasibility of one day analyzing DNA from Upper and even Middle Paleolithic populations in the Levant.

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Subsistence behaviour during the Initial Upper Palaeolithic of Bacho Kiro Cave (Bulgaria): zooarchaeological and taphonomic analysis across the Middle to Upper Palaeolithic transition

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Excavations at Bacho Kiro Cave during the 1970s [1] revealed a sequence spanning, in its lower part, the change from the Middle to the Upper Palaeolithic (MP/UP). Since then, the cave has been known for its rich faunal assemblages and the stone artefact record from level 11, the so-called 'Bachokirian'. Due to its Initial Upper Palaeolithic (IUP) character, this record has been critical in the debates about the timing and adaptations of early groups of Homo sapiens in Europe. Since 2015, new excavations of the cave have focussed on the periphery of the previous excavation area (the Main Sector) but also on preserved deposits in a new area, Niche 1. Niche 1 has produced considerable lithic (n=2351) and faunal (n=12,500) assemblages alongside fossils of Homo sapiens from the IUP of Layer I (previously level 11) [2]. While lithic material from Layer J is, in its upper part, technologically consistent with the assemblage from Layer I it is also found at a lower density. At the same time, some artefacts from the base of J are consistent with the underlying Middle Palaeolithic assemblage in Layer K. New radiocarbon ages for Layer I of ~45 ka BP [3] provide highly reliable chronological context of these finds and permit more detailed and integrative investigation of changes in subsistence behaviours of early *Homo sapiens* groups.

This paper presents the first results of our integrative assessment of IUP subsistence behaviour at Bacho Kiro. Species representation is similar that reported for the 1970s excavation, including high proportions of cave bear, red deer and *Bos/Bison*. Overall, species represent a mix of environmental settings characteristic of south-eastern Europe during marine isotope stage 3. Overall, fauna from these new excavations exhibits excellent preservation with very little weathering and an excellent preservation of bone surfaces. Detailed zooarchaeological analysis highlights that Layer I accumulated largely through human activities with high proportion of modifications including skinning, disarticulation, cut marks, and marrow fractures. This contrasts with Layers J and K where the intensity of carnivore modifications of fauna is significantly higher. The IUP deposits reveal broader exploitation of herbivore and carnivore species, which indicates flexibility in adaptation of these early groups of *Homo sapiens* in the region.

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Raw material selection and blank standardization in knapping experiments

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Hypothesis testing in experimental archaeology is a valuable tool for improving our understanding of the evolution of human behaviors and culture. By replicating the end-products of hominin behaviors (here, stone tools), we can fine-tune our hypotheses about the processes – biological, neurological, cultural, or otherwise - that led to their manufacture, and ultimately, we might better comprehend the hominins that produced them. Replication experiments in archaeology would benefit from an increase in reliability and validity, guided also by principles of the scientific method and controlled experimentation from the natural sciences [1] [2]. Controlled experimentation can be achieved by minimizing the contribution of extraneous and confounding variables to the measured effects being targeted by the researcher(s) (i.e., removal of raw material effects improves the resolution of cognitive and cultural data that can be attained) [2] [3]. In experimental archaeology, one option for accomplishing *reliability* is the standardization of the *blanks* – intended to be knapped by humans, machines or otherwise - in terms of material, shape and size [3]. In recent times, researchers have created (reasonably) standardized forms from materials such as glass and porcelain [3] [4]. As for *validity*, experimental blanks are best judged on their resemblance to archaeological counterparts in terms of mechanical properties (especially for non-archaeological materials like manufactured glass and porcelain) [3] and blank form [3] [4], among others.

Selection of raw materials can be time-consuming and can involve a great deal of sunken investment into unviable or unsuitable techniques and materials. There are considerable pragmatic and logistical difficulties involved in finding and procuring standardized raw materials for knapping experiments (e.g., low availability, high manufacturing costs, high labor input, unsuitable physical properties), with little published information about the selection process available to direct researchers away from unforeseen dead-ends (especially for ultimately unsuitable materials). To prevent the repetition of this search in other groups, we provide an abridged overview of the various raw materials that we have examined for their standardizability and validity. We emphasize materials and standardization techniques that represent arguably the best compromise between practicality (e.g., efficiency and easy of production of standardized blanks, monetary and personnel-related costs, safety concerns), standardizability and validity of physical properties (e.g., conchoidal fracture, ease of flake removal, sharpness of edges) for investigators working in the broad scope of archaeological replication experiments. The pursuit of a suitable and standardizable material for our own experiment(s) led us to those materials already highlighted in the literature (i.e., glass, porcelain and bricks), along with an array of other materials and standardization techniques that are, to our knowledge, not presently discussed in terms of their aforementioned viability (some of which we present here). Even with this guide, judgment is still required by the individual researcher or working group to determine which materials and techniques are most relevant to their research questions and most feasible and accessible to them.

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Reconstruction of vegetation and habitat at an early Acheulean site using leaf-wax lipids and isotopes: Thiongo Korongo (Olduvai Gorge, Tanzania)

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Early Acheulean sites at Olduvai Gorge show the complexity and variability of the *Homo erectus* behaviour. The highest concentration of early Acheulean sites recorded in Bed II at Olduvai Gorge allows the analysis of the *Homo erectus* behaviour during the early stage of Acheulean in a confined geographical frame. To comprehend this behaviour it is necessary to understand the habitat of hominin. A strong, positive correlation between technological innovations and landscape (ecosystem) change is considered to be a main driver of human evolution. Here, we focus on an important Bed II locality – Thiongo Korongo (TK) – that has some of the highest concentrations of autochthonous Acheulian stone tools at Olduvai Gorge, in an attempt to unravel key patterns in coeval landscape change and resource distributions via robust 'biomarker' molecular and isotopic analyses.

TK is situated 2 km east from the junction of the main and side gorges at Olduvai and stratigraphically is located in the Upper Bed II; TK is related to Tuff IID which has been dated by $^{40}Ar/^{39}Ar$ to 1.353 ± 0.035 Ma [1]. TK is one of the sites with the highest concentrations of autochthonous preserved Acheulian lithic tools. The remains are principally situated in two paleo-surfaces, named TK Lower Floor (TKLF) and TK *Sivatherium* Floor (TKSF) [2,3] that are stratigraphically close; there is not significant temporal diachrony [2]. However, the technological advancements of manufacturing the tools show strong differences amid the lithic industry and faunal remains between the two paleosurfaces.

Here, we report lipid biomarker of the TK sedimentological section (n = 12), including both TKLF and TKSF layers. We analysed the total lipid extract of these sediments, including n-alkanes, fatty acids (FAs), and stable carbon and hydrogen isotopic composition of lipids ($\delta^{13}C$ and $\delta^{2}H$). Plant leaves n-alkanes results show that the compounds were abundant and well preserved in the sedimentary section. Carbon preference index (CPI) values and average chain lengths of n-alkanes (ACL) show a prevalence of short-chain lengths, reflected in the aquatic index Paq (0.39 to 0.9). This means that the environment was dominated by submerged/floating macrophytes. All samples show abundant fatty acids, and the prevailing ones are C18:0, C16:0, and C22:1 FAs. Preliminary isotopes data suggest that the vegetation was characteristic of a wet environment dominated by aquatic plants.

These data provide the earliest evidence of early hominin technological advancements in relation to available plant resources and riverine environments.

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Biomechanics of the pelvic floor constrains the evolution of the human pelvis: A finite element approach

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Human childbirth is comparatively difficult. Rates of obstructed labor and birth-related morbidities, such as pelvic floor disorders, are well-documented and often are direct consequences of the tight fetopelvic fit. What constrains further evolutionary widening of the human pelvis to ameliorate this tight fit remains a hotly debated topic. One proposed explanation is the pelvic floor hypothesis, which states that a larger bony pelvis, specifically the dimensions of the midplane and outlet of the birth canal, would compromise the supportive capacity of the soft pelvic floor tissue. The pelvic floor is important for a number of reproductive and health functions in women (and partly also in men) and is subject to higher intra-abdominal pressure in upright humans compared to quadrupedal mammals. However, this hypothesis goes largely untested.

Here, we use finite element analysis to model the effects of variation in surface area - as a proxy for birth canal size - and thickness of the human pelvic floor on its displacement (i.e., deformation). Increased pelvic floor displacement has been shown to be crucial to the aetiology of incontinence and prolapse. We subjected the pelvic floor models to an intra-abdominal pressure of 4 kPa, which is within the normal range of pressure during daily activities. We measured the resulting displacements in the anterior and posterior compartments of the pelvic floor models.

Our results demonstrated that an increase in pelvic floor surface area leads to a disproportionately large displacement of the pelvic floor: it increases at a higher rate than the increase of the surface area. We also observed that pelvic floor thickness has a strong compensatory effect on the displacement by increasing pelvic floor stiffness. But even when thickness is increased isometrically with surface area, the pelvic floor descends disproportionately. In sum, we have obtained novel evidence in support of pelvic floor functionality acting as an evolutionary constraint on the size of the human birth canal. Furthermore, the observed buffering effect of thickness on displacement implies that an evolutionary increase in birth canal size, and thus in the surface area of the pelvic floor, need not compromise pelvic floor support as long as pelvic floor thickness were to increase disproportionately with surface area. But while such an increase in thickness would be beneficial for continence and support of the gravid uterus during pregnancy, it might be disadvantageous for childbirth as has been shown in studies of elite athletes. The thickness of the pelvic floor may thus be subject to an evolutionary trade-off dynamics, similar to that driving the area of birth canal and pelvic floor size.

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Life in the margins: the pre-Still Bay deposits from Varsche Rivier 003, southern Namaqualand, South Africa

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The Middle Stone Age (MSA) of Africa is generally recognized as a period of increasing technological complexity and as the source for all living humans. In southern Africa, much attention has been focused on the Still Bay and Howiesons Poort industries, but less to the earlier MSA, especially from more marginal environments. The pre-Still Bay deposits from the limestone rock shelter Varsche Rivier (VR) 003, South Africa, provide an opportunity to examine earlier behavioral evolution. VR003 is located in the Knersvlakte, the quartz-gravel plains of southern Namaqualand, currently a low-rainfall region that likely experienced more favorable conditions during the Late Pleistocene when it was cooler and wetter.

Since 2009 we have conducted five seasons of fieldwork that have revealed a substantial sequence of early MSA deposits, as well as younger components of the MSA and late Holocene Later Stone Age in the shelter as well as on the terrace slope in front of the shelter [1,2]. Here we present results from the deepest component of the slope context (Sector I) where we excavated into the early MSA. Geoarchaeological and micromorphological analysis reveals that calcareous silt, calcite crystals and limestone fragments present the main sediment source, resulting from weathering of the limestone. Rounded aeolian fine sand to silt and subangular coarse grained quartz grains from the quartz rich plateau above the site are also regularly present as well as microscopic bones. We also observed some slope deposit effects with coatings of grains and rounded transported aggregates. We are employing optically stimulated luminescence of the quartz and feldspar components of the sediments and ^{230}Th/U dating of ostrich eggshell to reconstruct the chronology of deposition.

The lithics include common notched and denticulated flakes, with silcrete the dominant material. Evidence for heating is abundant; ~90% of the silcrete cores show evidence of thermal alteration before flaking. The majority of cores were fractured by heat before flaking, and the fractured pieces were exploited, providing evidence of an early, low-investment approach to heat treatment. The fauna and ostrich eggshell are also extensively burned; we did not observe hearths, but micromorphology samples preserve microscopic fragments of charcoal and heated bones. The faunal remains indicate wetter, grassier conditions; eland are abundant, along with wildebeest/hartebeest and zebras. Similarly, secondary gypsum formations throughout the sequence indicate a switch from wetter to later dry conditions. The presence of marine shell (primarily limpets and black mussel) provides an indicator of site catchment area, because VR003 is currently 43 km inland. Some of the early MSA OES appears to be flaked, and could represent flask apertures. The recovered marine shells, flasks, and pigments have patterned distributions which reveal changes through time.

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Further evidence for a late onset of cumulative culture: Ape cultures do not require copying of know-how

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Human culture is cumulative in its products and underlying processes. We are all giants standing on the shoulders of … somewhat smaller and smaller giants - all the way to an uncumulated size. Human cultural evolution requires the ability to copy know-how – i.e. the ability to reproduce goal-directed behavioural strategies of others. This know-how can be social (e.g. learning dance steps or rituals), but it can also be physical (e.g. learning to make a steam-engine). It is widely acknowledged that humans can and do copy know-how, and indeed, without it, technology could not have come about that is empirically so complex that nobody can reinnovate it entirely from scratch. Human culture rests on – and requires – an ability to copy know-how.

When did uncumulated know-how give rise to cumulated know-how? When did we start to transform into know-how giants to stand on? One viewpoint holds that the ability to copy know-how is widespread among non-human great apes (apes) today – i.e., that ape cultures today consist, at least in part, of ape to ape copying of know-how. If correct, we may conclude that the copying of know-how likely existed already in the last common ancestors (LCA). However, if this view is incorrect, then the copying of know-how likely would not have existed in the LCA – in which case the copying of know-how would have had to occur first (at least among apes) in hominins, i.e. after the LCA.

Thus, it has become of interest whether apes show copy know-how. We know that human-trained and/or human-enculturated apes can, albeit crudely - but their performances are phylogenetically irrelevant. Instead, we need to know if wild or wild-like apes can. Those in favour of the view that wild apes copy know-how often point to the existence of stable cultures across wild ape populations. But we and others have argued that such patterns do not logically require the copying of know-how and therefore cannot pinpoint know-how copying. Instead, mere know-how frequency-regulating mechanisms - socially mediated individual reinnovation of know-how - should produce wild ape cultural patterns. This is the so-called zone of latent solution hypothesis (ZLS) by Tennie et al. But what was lacking in this debate was a formal model exploring the issue empirically.

To do an empirical examination, we created an agent-based model to test whether wild ape cultural patterns can indeed emerge and stabilize in the complete absence of any copying of know-how when only social-mediated reinnovation of latent know-how was possible. In such a model, the frequencies of know-how reinnovation remain under social learning influence, but not the actual forms of the know-how (which had to derive individually instead, in strict accordance with the ZLS).

Our agent-based model closely modelled wild ape life parameters, including various individual needs and population demographics. We also varied the influences of genetic and ecological factors. Our result proved very stable across various settings. Our model reproduced wild ape cultural patterns – i.e. ape cultures – well. Our results therefore empirically show that ape cultural patterns - both in their emergence and stabilisation – indeed do not require any copying of know-how. Together with additional empirical findings of real-life ape cognition (an absence of evidence for spontaneous ape action copying, and a presence of the ability to individually and spontaneously show evidence for wild-type know-how) our findings strongly support the hypothesis that apes are restricted to their ZLS – to their range of individually reinnovatable know-how. Compared to other animals, the ape range of innovation remains impressive – they are giants among animals in this respect – but apes are not giants that build by standing on each other. Human copying of know-how may therefore indeed be unique among apes and it therefore likely arose at some point after the LCA – i.e., it arose in hominins.

Spatial and temporal variations of the diet in *Mesopithecus* (Colobinae, Primates) from the late Miocene of southeastern Europe

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Background: Extant colobine monkeys are specialized folivores, to the point that they evolved physiological and morphological adaptations to leaf consumption. But during the late Miocene, Europe was home to colobine monkeys which were less efficient at chewing leaves than they were at breaking seed shells. Several authors have proposed that granivory could have been an intermediate grade between the folivorous diet of extant colobine monkeys and the frugivorous diet of stem Old World monkeys, such as victoriapithecines. Still, it is not known when and where the shift from granivory to folivory would have occurred.

Objective: We investigated broad- and fine-scale variations in the dietary niche of the genus *Mesopithecus* within southeastern Europe, where a major environmental change occurred during the late Miocene.

Methods: We used dental topography, which detects long-term, evolutionary driven changes in tooth surface morphology, to estimate the leaf- and seed-chewing efficiency in two extinct species, *M. delsoni* from MN11 and *M. pentelicus* from MN12. Molar relief was estimated using slope and molar sharpness using area-relative curvature (ARC). We then compared dental topography with microwear textural complexity of enamel wear facets (Asfc), which is a direct assessment of seed and/or grit abundance in diet. We used a comparative sample of the same 11 Old World monkey species, using (1) unworn upper second molars for dental topography and (2) the crushing and shearing facets of both upper and lower molars for dental microwear textural analysis.

Results: We found that M. delsoni might have been more efficient at chewing leaves than *M. pentelicus*, the low slope and ARC of which matches an opportunistic seed eater such as *Chlorocebus aethiops* or *Lophocebus albigena*. Concurrently, microwear complexity increases in *M. pentelicus* compared to *M. delsoni*, especially in the northernmost localities corresponding to present-day Bulgaria. This increase is interpreted as a dietary shift towards hard foods such as seeds or underground storage organs in *M. pentelicus*, particularly in the savannah and open mixed forest biomes which covered Bulgaria during the Tortonian.

Conclusions: The fact that *M. delsoni* would have been more specialized in folivory than the later species *M. pentelicus* suggests that colobine monkeys either adapted to leaf consumption before the dispersal of *Mesopithecus* to Europe, or evolved (dental) adaptations to leaf consumption in multiple occurrences. As its preferred biotope became increasingly fragmented in southeastern Europe, the less versatile dental morphology of *M. delsoni* likely played a role in its local extinction between MN11 and MN12. This work demonstrates that combining dental topography and microwear textural analysis can give us important insights into the dietary niche of extinct primates, and into the impact that environmental changes could have had on their actual diet.

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Incorporating structure into demographic models of the deep past: a case study from Late-Middle Pleistocene Africa

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Diversity within the African Late-Middle Pleistocene archaeological record is becoming increasingly associated with the presence of structure in early hominin populations. It has been proposed that complex migratory patterns of early human populations, facilitated and restricted by varying environmental conditions through time, led to reticulate interaction networks across the landscape. As such, we now consider human evolution to be a structured and complex process [1], yet few studies have been conducted to quantitively test or model this [2,3]. Our paper will discuss the importance of considering population structure in demographic models of early H. sapiens [1]. Initial work on a climatically driven model of early human interactions will be reported, using new high-resolution simulated data from the Global Climate Model Emulator (GCMET) [4]. Conditions conductive to human habitation have been mapped using species distribution modelling to show how regions were interconnected through space and time, allowing for an exploration of how areas of hominin occupation and the potential corridors between them shifted. Correlating these patterns of connectivity with variation in fossils and archaeology will later provide a fruitful test of the model's predictions, specifically hominin crania and MSA projectile points which are routinely cited to be effective proxies for group interactions during this period [1]. Complex demographic such as this will no-doubt be needed to explain the ever-richer African Late-Middle Pleistocene archaeological, fossil and palaeoenvironmental record. In addition, they will be integral for the development of new theory and methods for understanding past prehistoric populations. What's more, identifying structure in *H. sapiens* prior to dispersal beyond the continent will have major implications for the nature of such migration events [5], and subsequently their effects on the global evolution of modern human diversity.

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Is human brain organization economical?

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The human brain is responsible for 20% of the resting metabolic rate of the body. It has more than tripled in weight since the human and chimpanzee lineages diverged. This relatively recent increase in maintenance costs must have been met by either a reduction in energy expenditure by other costly functions such as digestion, or by an increase in energy turnover due to dietary shifts such as animal consumption and cooking. However, just as different organs consume energy at different rates, structures within the brain also vary in energy expenditure. The metabolic cost per unit brain tissue decreases as brains get larger because larger brains have a greater fraction of white matter to gray matter, and white matter has a lower metabolic rate than gray matter. These tissues differ in that grey matter is composed of neuronal cell bodies, dendrites, and shorter axons, whereas white matter is composed of the long axonal connections between. Therefore, the metabolic differences are thought to be linked to differences in cellular composition. In particular, increases in neuron number, size, and complexity, may be linked to higher energetic demands, which are also supported and influenced by glia. Yet, on a microorganizational level, little is known about how species variation might explain variation in their brain metabolic rates. Further, it might be possible for two brains of the same size to have different energy requirements if they are organized differently.

For primate brains in the Stephan collection, we examined whether there was a relationship between human brain regions' cerebral glucose metabolic rates and the extent to which they changed in size in human evolution, based on nonhuman primate phylogenetic predictions of brain structure volumes. We did not find a significant relationship in our dataset. We further examined whether brain region metabolic rates influenced changes in brain organization that occur during human life history. We found no significant relationships between brain region metabolic rates and changes in volumes during development and ageing, which is in agreement with recent work in a rodent model. Although we found that neuron and glia density were not significantly related to regional metabolic rates, we found that the ratio of glia density to neuron density was related linearly to regional cerebral metabolic rates. Astrocyte, oligodendrocyte, and microglia density were also related linearly to regional cerebral metabolic rates. Based on these findings, instead of looking at regional data we then examined whether there were trends when comparing whole brain metabolic rate to data about cellular composition across species. Our findings suggest that some aspects of brain organization may be constrained by variation in brain region metabolic costs.

The Initial Upper Palaeolithic lithic assemblage from Bacho Kiro Cave (Bulgaria)

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We are reinvestigating the Palaeolithic landmark site of Bacho Kiro Cave since 2015. The cave is located in the middle part of the Balkan mountain range in central-north Bulgaria. The previous excavation from the 1970s [1] discovered a sequence spanning from the Middle to the Upper Palaeolithic with an early Upper Palaeolithic assemblage known as Bachokirian from Layer 11. From a typo-technological perspective, the presence of Levallois technology combined with Upper Palaeolithic tool types [2] has led to an attribution of the Bachokirian to the so-called Initial Upper Palaeolithic (IUP) of Eurasia [3]. The new excavation produced a stratigraphy similar to the one published previously based on the work in two separate areas. In the new system, Layer I corresponds to the Bachokirian of Level 11. New human remains from this layer and their radiocarbon ages show the presence of <Homo sapiens> in Europe around 45 ka BP [4, 5]. The large lithic and bone assemblages (n=2,351 and n=12,500) are well preserved and several lines of evidence suggest an anthropogenic accumulation of the Layer I.

Here we present the lithic assemblage from Layer I. We excavated the largest sample of this material in the Niche 1 sector. The lithic assemblage is characterised by: 1) artefacts primarily made on different types of allochthonous, fine-grained flint from the residual formations of the Aptian (71,3 %) and Campanian (21,1%) limestone formations respectively located between 150 km to the northeast and 80 km to the northwest from the site, repsectively; 2) a high proportion of burned artefacts (≈ 15%) and weathered surfaces (≈ 90 %); 3) data suggesting off-site production and transportation of finished products into the site; 4) a high rate of blade fragmentation (78,8 %) and intense reduction of the blanks and tools by bipolar knapping (redébitage and reshaping); 5) bladelets and small flakes obtained from core-on-flake and bipolar on-anvil percussion; 6) morphological and typological variability among pointed blades; 7) artefacts with facetted platforms (12% blades and flakes) and a morphology close to Levallois and a blade production technique that is consistent with direct percussion by hard hammer (93%); 8) use-wear analysis that shows evidence for selective use of blades, either with unmodified or retouched edges; and 9) absence of lithic and osseous elements commonly associated with Aurignacian. This set of features is consistent with a view of the Initial Upper Palaeolithic [3] that shows broad similarities across a large portion of Eurasia but that at the same displays much regional variation. At Bacho Kiro, the IUP follows the local Middle Palaeolithic and on a larger scale precedes bladelet dominated early Upper Palaeolithic assemblages like the Ahmarian, Protoaurignacian and the local Early Kozarnikian. The connections between these technocomplexes and their chronologies on a regional scale, across Europe and into southwest Asia are still far from clear, and it is possible as indicated by the mtDNA result [4] that at Bacho Kiro the IUP is demographically unrelated to the subsequent Upper Palaeolithic.

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Combining fossil enamel stable isotopes and dental microwear texture analysis to assess dietary niche-partitioning among primates (Cercopithecidae and Hominidae) from the Lower Omo Valley, Ethiopia.

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As the sole surviving hominin lineage, the evolution and reasons for the persistence of the genus Homo are of great scientific interest. Diet is an important aspect of hominin ecology that may help explain key ways in which Homo differed from other hominins and primates. Tooth enamel geochemistry and tooth wear are two methods for investigating diet which are widely applied on their own and increasingly, in tandem. Here, we combine stable isotope analysis and dental microwear texture analysis (DMTA) of hominin and cercopithecid molars from the Shungura Formation in the Lower Omo Valley, Ethiopia, to study diet type and dietary niche partitioning of these taxa. We focus on the period from ~2.3 to 2.0 Ma because of the high taxonomic diversity of cercopithecids and hominins, the former represented in this study by *Theropithecus*, *Papio*, and the colobines *Paracolobus* and *Rhinocolobus*, and the latter by *Australopithecus*, *Paranthropus*, and *Homo*.

We developed a DMTA-based dietary morphospace using PCA of 20 textural characteristics on a data set of four extant primate species (n=104) with different dietary preferences. In the DMTA morphospace, fossil *Theropithecus* (n=44) falls near its extant congener, the gelada, whereas fossil *Papio* (n=32) lies closer to modern vervets than their extant counterparts. Smaller sample sizes of the colobines (n=9) show the extinct *Rhinocolobus* had a diet most similar to the arboreal *Colobus guereza* whereas the terrestrial *Paracolobus* had a highly variable diet, including hard objects. For the hominins, DMTA data show no evidence of durophagy. The diet of *Paranthropus* (n=10) falls closest to that of extinct and extant *Theropithecus*. Smaller data sets for *Homo* (n=4) and *Australopithecus* (n=2) suggest variable diets that fall farther outside of the extant primate morphospace compared to *Paranthropus*.

Carbon isotope (d13C) data from cercopithecids and hominins show *Paranthropus* (n=18) and *Theropithecus* (n=19) both had C4-dominated diets, thus overlapping in both d13C and DMTA space. *Papio* (n=11) shows a high range of d13C values, mirroring the high diversity in the DMTA PC1 dimension. The diet of *Homo* (n=10) spans C3- to nearly C4-dominated values and overlaps considerably with *Paranthropus*. *Australopithecus* (n=4) has a wide d13C range; colobines (n=9) have C3 diets, but based on DMTA results, sourced different foods. The combined isotope and DMTA data reveal complex dietary niche partitioning among hominins and primates.

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Quantifying the energetic cost of chewing in humans and its evolutionary significance

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Chewing efficiency (change in particle size/chewing work) is one of the foundational concepts used to understand the functional morphology of the feeding system. It is assumed that lower masticatory efficiency will impact the net energy gained from foods. Major evolutionary changes in hominin craniofacial morphology are often explained in terms of energetic optimization for the consumption of various diets. For example, the enlarged masticatory system of early hominins has been proposed as an adaptation enabling more efficient chewing of large volumes of mechanically challenging foods. Similarly, modern humans after the adoption of cooking and tool assisted food preparation emancipated themselves from lengthy chewing times. This is a marked contrast to extant non-human great apes that can spend up to 54% of their day chewing. Such a reduction in daily chew times likely provided early members of our lineage with some net energy gains. However, to understand if the role of chewing energetics was influential in shaping the hominoid feeding system, there must be quantitative data on the energetic costs of chewing. Currently such data are scant and the actual energetic costs of chewing in hominoids have never been quantified, despite the proposed strong evolutionary pressure to maximize chewing efficiency.

We collected data using mask respirometry to measure energetics and electromyography (EMG) to determine activity of the masseter of 25 human volunteers chewing flavourless gums of low and high stiffness. Chewing of both gums results in a significant increase in energy expenditure (kJ/min) relative to basal metabolic rate (mean ±sd = 4.26 ±0.53), with stiffer gum (4.91 ±0.59) always requiring more energy than the compliant substrate (4.69 ±0.54) (paired sample t-tests all $p<0.000$). The compliant gum was chewed at a higher frequency, but with lower peak EMG value when compared to the stiffer gum. Extrapolated over average daily chewing times, the cost of mastication in humans is well below 1% of total energy expenditure (TEE). Apes chew longer, thus chewing may account for up to 4% of their TEE. This suggests that at least in modern humans, selection on chewing efficiency is likely biased towards traits, like tooth morphology, that facilitate food breakdown rather than energetic considerations. Strong selection to conserve chewing energetics is likely found only in primates that spend a large amount of time masticating, such as early hominins.

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"Footedness" in orangutans: A Geometric Morphometric approach to understanding lateralisation in Great Apes

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Lateralisation describes the division of an animal's brain into two hemispheres which are specialised in different functions [1]. This was long believed to be a uniquely human trait and was associated with our enhanced cognitive abilities, capacity for language and hand preference, especially in connection with tool use [2]. We now know, however, that lateralisation is to some degree present in a wide range of vertebrates [3,4]. Limb preference is a form of lateralisation in which each cerebral hemisphere controls movement of the opposite half of the body. Limb preference is particularly well documented in humans, with the vast majority of adults in a population having a preferred hand and foot. Whether such a preference is also present in our closest living relatives, the great apes, is an important question for our understanding of how and when limb preference evolved. However, past studies have at best provided limited and sometimes conflicting evidence for limb preference in non-human great apes. The vast majority of past work has relied on behavioural observations, which are often limited in sample size and task specific. Recent advances in geometric morphometrics allow us to observe slight differences in the shape of anatomical features due to differential rates of mechanical loading, thus potentially indicating an individual's favoured limb.

In this study, the pedal phalanges of eight orangutan specimens from the Zoologische Staatssammlung München were CT-scanned and 3D models created. A series of sixteen landmarks was then applied to the surface of these models. A further two series of twenty landmarks were applied to describe both the inner and outer curves of these bones. A generalised Procrustes analysis was then applied to the coordinates of these landmarks, to remove variation in size, rotation and position of the specimens. Shape variation was then explored using principal component analysis and visualized via 3D morphing. Pairwise differences in centroid size and shape between the phalanges from the left and right sides of the body were analysed using a paired Procrustes ANOVA.

Results of this analysis showed no evidence for left-right differences in either centroid size or in the inner curvature of the specimens. However, pairwise left-right differences were observed in the overall shape of the 3rd, 4th and 5th phalanges, although not the 2nd phalanx. The outer curves of the 2nd and 4th phalanges also displayed evidence of asymmetry. The results of this study lend further support to the presence of a foot preference in orangutans. However, whilst certain aspects of the pedal phalanges show asymmetry, others do not. This could potentially be explained by different aspects of the phalanx morphology playing different roles in arboreal locomotion, not all of which would benefit from foot preference.

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Preliminary results of the first geoarchaeological analysis of cave sediments from Kazakhstan

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Semi-arid Central Asia is an understudied but important region for understanding human evolution in the Late Pleistocene [1-2]. In particular, some Central Asian caves as Obi-Rakhmat [3] and Sel'Ungur [4] have provided a secure context of long archaeological sequences with multi-layered occupation assemblages and human remains. However, a systematic geoarchaeological analysis of cave sediments has not yet been carried out on a regional scale. Our recent work in the piedmonts of south and eastern Kazakhstan highlighted systematic biases in different geomorphic and sedimentary contexts and provided directions for conducting future archaeological research in the region [5]. Nevertheless, to supply predictive models with field data, the formation processes that shape this terrain must be investigated. Therefore, this study addresses these processes within cave contexts. We first present statistics on the presence of sediment in caves and rockshelters based on the total number of features surveyed and test-excavated during the fieldwork seasons of 2018 and 2019. Then, using macroscopic observations on stratigraphy, cave morphology, and micromorphological analysis, we draw examples from cave sites in the Qaratau mountains and explore the characteristics of their sediments focusing on source, depositional and post-depositional processes, and erosion. Our preliminary results show that 27% of the surveyed caves contain sediment. Sediment thickness varies and thicker sequences tend to be associated with caves that also contain Holocene occupation. Deposits of presumed Pleistocene age are found in only a few sites. Our analysis suggests that loess appears to be the dominant sediment source for the majority of caves. Loess deposits in the caves are generally not in primary position but appear to have been reworked with other cave materials and are rarely homogeneous. Water-lain sediments are frequent, contrasting with the contemporary dry micro-environment encountered in most of the caves. Chemical diagenesis is limited and the presence of coprolites and other biogenic inclusions demonstrates that Kazakh caves can preserve organic remains. However, micromorphological evidence indicates that mass movement processes are in some cases responsible for the post-depositional erosion and mixing of sediments. Overall, cave sediments in Kazakhstan are good mediums for the preservation of archaeological remains when present. Our study is the first to address the status of cave sediments in Kazakhstan and has broader implications for our understanding of cave formation processes in semi-arid Central Asia.

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An integrated techno-functional study discloses chopping tools use at late Acheulean Revadim (Israel)

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Chopping tools represent one of the earliest and long-lasting evidence of stone tools produced by early humans during the Oldowan and Acheulean cultural complexes throughout the Old World. These artefacts were manufactured, and presumably used, by early humans throughout a period of over two million years and witnessed major transformations in human cultural and biological evolution. However, it seems that chopping tools went through little technological changes during these long periods, and thus are one of the most persistent stone-tools manufactured and used by humans.

Despite their widespread distribution through time and space, little is known concerning their function while scholars still debate whether these are tools or cores. Apart from very early attempts to technologically classify these items, we actually know very little about their role in the tasks performed using early stone-tool assemblages. The purpose of their production is still not agreed upon among those who argue that they have to be considered preconceived tools designed for a specific function, while others interpret them as discarded cores after the desired flakes have been removed, notwithstanding the fact that direct evidence for both claims was never presented.

Following these premises, we discuss here a sample of 53 chopping tools retrieved from the late Lower Paleolithic Revadim site (Israel). By adopting an integrated approach including technological observations, experimentation and use-wear analysis, coupled with morphological and chemical analysis of residues we demonstrate that chopping tools were expressly used during specific stages of the animal carcass processing. Many show signs of pounding activities on medium and hard materials as bone, probably for marrow extraction purposes. Functional interpretation was strengthened by outstanding diagnosed micro residues of bone, fat and different type of collagen fibers, confirming the already noted exceptional preservation condition of this particular layer at the site. The data are discussed in light of functional results of a sample of cores and cortical flakes retrieved at the same location in order to provide a more comprehensive understanding of the tool versus core debate and the dichotomy between light and heavy-duty components in early Paleolithic assemblages.

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Early American colonisation: Life on the White Sands National Park playa in the Pleistocene

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Understanding the route(s) and timing of human colonisation of the Americas has become something of a scientific obsession; the last chapter in the 'Out of Africa' story. It is a story linked with the end-Pleistocene extinction of megafauna and therefore potentially the start of the Anthropocene. The role of Paleoindian foragers in the extinction of megafauna in the Pleistocene has remained controversial ever since Martin first proposed the 'over-kill hypothesis' [e.g., 1]. At various points since then, opinion has been polarized between those that advocate extinction via 'over-kill' [e.g., 2] and those that favour climate and/or environmental change [e.g., 3]. The chronological coincidence between colonization and extinction is no longer clear; especially as migration routes and timings are uncertain, given tension between DNA chronologies and environmental practicalities of different migration corridors [e.g., 4].

Recent work at White Sands National Park (WHSA) in New Mexico has demonstrated how the human ichnological (fossil footprints) record can play an important part in understanding the co-association and behavioural ecology of late Pleistocene human foragers with that of extinct megafauna. This site forms probably the largest collection of late Pleistocene human footprints in the world, and allows animals of all types to be tracked over extensive distance thereby allowing their behavioural ecology and interaction to be studied. Footprints provide insight into the behavioural ecology of both humans and other animals, as well as their interaction. Tracks/trackways at WHSA occur with sufficient frequency and over extensive spatial scales to allow Pleistocene animals to be tracked and behavioural inferences made on their association with human trackways on a much larger scale than what has been reported previously. Here, we report the longest double human trackway in the world which is age bracketed by giant ground sloth and Columbian Mammoth. A human adolescent made two journeys separated by several hours, carrying a young child (<3 years) in at least one direction. Despite the presence of giant ground sloth, dire wolf, and Columbian Mammoth in the immediate vicinity, the human trackways show no prey awareness other than haste. In contrast, giant ground sloth show behaviour consistent with human predator awareness, while mammoth tracks show no apparent predator awareness. The footprints of the human track-maker have varied morphology and left-right asymmetry, which might be due to child carrying – intermittent small child prints appear along the trackway, suggesting that the track-maker was travelling with a small child. We explore this morphological variability using methods based on the analysis of objective track outlines, which adds to the analytical toolkit available for use at other human footprint sites. In addition, the sheer number of tracks and their remarkable morphological variability allows us to explore the reliability of inferences made from human footprints when faced with much smaller samples representative of more typical footprint sites. One conclusion is that the sample footprints required to make reliable inferences from sites such as these is larger than often assumed, and it is only with the discovery of this unique snapshot in time of the longest known human fossil trackway (>1.5 Km) can we have reached such a conclusion.

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Tinshemet Cave Project: Exploring a new Middle Paleolithic human fossil site in Israel

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Tinshemet Cave, central Israel, is a newly excavated Middle Paleolithic (MP) site bearing articulated human remains in the Levant. The cave is composed of three chambers and a terrace. Excavations at the site were launched in 2016 and MP layers were found on the terrace and in the first chamber of the cave. The terrace contains cemented sediments (breccia) rich in lithic artifacts and animal bones. The first chamber contains soft MP sediments. The lithic assemblages are characterized by the use of the Levallois method for the production of flakes. Initial geoarchaeological analyses indicate human use of fire. Faunal remains represent an array of local MP species, possibly showing greater emphasis on large-bodied game. The remains are dominated by aurochs (Bos primigenius), Mesopotamian fallow deer (Dama mesopotamica), mountain gazelle (Gazella gazella) and equids. Humans seem to be the primary accumulation agents.

During the 2017-2019 excavation seasons, the remains of at least 5 human individuals associated with rich Middle Paleolithic archaeological assemblages were discovered at the cave. Among the human remains, a fully articulated skeleton was discovered in breccia on the terrace of the cave and a partially articulated skeleton of a child was found in the first chamber. The anthropological assemblage also contains two skulls, which are still under excavation, along with several isolated teeth, which were found in different parts of the cave. The Tinshemet fossils have not yet been taxonomically identified and they could represent a population of *H. sapiens*, Neanderthals, or other late Middle/early Late Pleistocene hominins. After just four seasons of excavation, Tinshemet Cave has already yielded the largest Middle Paleolithic anthropological assemblage excavated in the Near East during the last few decades. These discoveries reignite the debate on the timing and pattern of human dispersals and interactions in the Middle Paleolithic. Our research objectives are to determine what *Homo* species inhabited Tinshemet Cave, to establish a secure chronology for the site and the hominin remains and to characterize the cultural and technological behavior and subsistence strategies of the hominins that inhabited the cave. In this talk, we present the site, the first results of the excavation, and discuss them within the wider late Middle/early Late Pleistocene archaeological and fossil record.

Molar enamel thickness distribution and hominid taxonomy

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There is considerable evidence from extant and extinct primates that the structural organization of the mineralized dental tissues holds a significant amount of (paleo)biological information suitable for assessing taxonomy, phylogenetic relationships, functional and adaptive strategies, and for reconstructing the evolutionary history of various primate clades [1]. Enamel thickness (ET) variation patterns in hominids stem from an evolutionary compromise between functional/adaptive constraints and strict control mechanisms of the morphogenetic program, though variability is also presumably affected by a number of biological and environmental factors [2]. ET is useful for tracking diet-related structural adaptations, and for exploring life-history trajectories, phylogenetic relationships and evolutionary trends [1-3]. However, considering the number of factors at play, the value of the ET's taxonomic signal remains unclear, particularly at sub-genus taxonomic levels.

ET is commonly assessed using either bi-dimensional measurements directly performed on fractured crowns or physical ground sections, or non-invasive bi-/three-dimensional approaches such as microtomography [1]. The most common variables used to quantify hominid ET, the average and relative enamel thickness indices, only partially discriminate among extant apes and show overlap among fossil and extant hominin taxa [3]. On the contrary, examining enamel distribution across the whole crown avoids average estimates (generally limited to a gradient scale of single values) and allows a characterization of ET in relation to crown morphology. Indeed, topographic patterning based on qualitative descriptions of ET cartographies suggests that australopiths exhibit thick enamel over the cusp tips, while in *Homo* relatively thicker enamel is found at the cusp base [1,2,4]. In order to quantify ET distribution patterns in a more comprehensive and statistically robust manner, we developed a new analytical approach based on advanced virtual imaging [5] and tested it on a selected sample of fossil and extant hominids.

The study sample includes unworn/minimally worn upper/lower first permanent molars (M1) of extant apes (*Pan*=10/10, *Gorilla*=10/10, *Pongo*=10/10), Plio-Pleistocene non-human hominins (*Australopithecus africanus* = 6/10, *Paranthropus robustus* = 6/10), and representatives of our own genus (Neanderthals = 10/10, extant humans = 10/10). The method used here enables statistical comparisons of ET maps by performing a registration using morphological features between a reference surface and the occlusal surfaces of each crown. Using PCA, cross-validated between-group PCA and cross-validated LDA, our results show that the extant taxa are well discriminated from each other (classification accuracy for bgPCA CV=97.5%/92.5% and for LDA CV=92.5%/92.5%). The Plio-Pleistocene hominin genera (*Australopithecus* and *Paranthropus*) are well discriminated from the human representatives. While having relatively thinner enamel compared to modern humans, Neanderthals plot close to or within their range. Our tests indicate that, even where absolute or relative ET indices do not sufficiently discriminate among *Australopithecus*, *Paranthropus*, and *Homo* (usually to the exception of Neanderthals) [3,4], the ET distribution patterns have high taxonomic significance.

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Quantifying the lateralization in the upper limb of historical human populations: a detailed study of the cortical bone distribution in the humeral diaphysis

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The study of long bone morphology in modern human and fossils hominins plays a central role in understanding the pattern of physical activity during the life of individuals and, by extension, to the more general living conditions of populations [1]. The quantification of long bones robusticity and the analysis of long bone shape allows to reconstruct long-term repeated stress, due to occupational or physical activities. In fact, the remodelling of the cortical bone of the diaphysis is related to a skeletal response to biomechanical loadings during lifespan. Several studies [2,3] have noted males showing a higher degree of bilateral asymmetry in the humeri than females; this observation has been related to sex-specific differences in activities and division of labour. In this study we investigate the pattern of distribution of the cortical bone in the humeral diaphysis in an explorative sample including 12 individuals (9 male, 2 female and 1 indeterminate) with both right and left humeri acquired via Computerized Tomography. It represents a preliminary approach to the study of the variability between population from early Middle Ages in Italy.

On each humerus we extracted 61 cross sections along the diaphysis from the 20% to the 80% of the total biomechanical length. On each cross section we calculated 48 equiangular semilandmarks: 24 on the periosteal and 24 on the endosteal contour by using the *morphomap* R package [4]. Then, we determined the thickness between paired semilandmarks (periosteal and endosteal) and we built morphometric maps of cortical thickness for each individual. Eventually, we computed the difference between right and left sides and mapped the differences in morphometric maps. In this way, the diaphysis is unrolled and the differences in thickness along the direction (anterior-lateral-medial-posterior) and the longitudinal axis are reported respectively on the x and y axis.

Our exploratory examination confirms the hypothesis that this sample, mainly composed of males of the working class, shows different levels of robusticity. We also notice that, in right humeri, antero-medial part of the diaphysis is thicker than in left humeri; particularly, in five individuals we found the dominance of a side (2 right dominance and 3 left). We hypothesize that the observed bilateral asymmetry is probably due to specialization in occupational activities. These preliminary results, in turn, give support to the adoption of the methodology we tentatively used here. Therefore, it can be now applied to a wider sample of populations between the Roman times and the Middle Ages.

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Like father like son. Long legs and wide hips also reduce the cost of locomotion in subadults

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Biped locomotion is essential to human physical activities, and specially in those required to obtain resources. Due to the importance of human locomotion, the existence of some behavioural and morphological features to save energy that could be invested in other necessities, as individual maintenance, development or reproduction, may be expected. So, it is suggested that selective pressures could affect human morphology to favour locomotion efficiency. Several studies propose that some anatomical features, as larger legs or wider hips, reduce energy expenditure during locomotion (EE), due to an increased stride length or because of the reduction in the number of steps. Humans reach gait maturation between 8 and 10 years of age. Because of the importance of locomotion activities for playing and learning, we would expect the adult morphological features that save energy to emerge during the immature stages. Besides, leg length growth starts prior the pubertal body spurt. It is known that leg length influences the cost of locomotion, thus, the early ontogenetic development of this character might be related to a reduction in the cost of locomotion in children. The main purpose of this study is to test whether the anatomical features that have been shown to reduce the energetic cost of walking in adults effect also and in a similar way in subadults.

An experimental study was developed with 25 males and 17 females between 8 and 14 years of age. Each volunteer carried out 5 minutes outdoor walking tasks over 290, 333 and 500 meters, attaining speeds (V) of 3.5, 4, and 6 km/h. Walking EE was monitored using the Oxycon Mobile JAEGER® device. Body Mass (BM), Bi-iliac breadth (BIL) and Femur Length (FL) were measured with a digital scale to the nearest 0.1 kg and an anthropometer nearest to 0.1 cm. Multiple stepwise linear regressions via forward were computed, including BM as a covariate, to explore the relationship between BIL and FL and the energetic cost of locomotion trials (selection criterion to enter $p<.05$). Besides, a speed factor (V) was included into the multiple regression since it is known to be a fundamental factor in the cost of locomotion.

Moreover, BM and V, BIL and FL display significant correlations with EE ($R^2=.71$, $p<.001$) as revealed in previous studies on adults [1,2,3]. The main factor that determines EE is V, followed by BM, while a wider bi-iliac width and a longer femur decrease the cost of locomotion (Partial correlation: .807, .488, -.390, -.236, respectively). These results are similar to those obtained by Vidal-Cordasco et al. [1] for the locomotion of adults. However, our results show a minor influence of FL and a higher effect of BIL on energy expenditure. These differences might be explained by the effect of speed, since Vidal-Cordasco et al. carried out their experiments at a constant velocity of 4 km/h. A wider BIL might provide more stability and lesser cadence at higher velocities. Besides, children show higher tibial growth relative to the rest of body proportions [4], therefore FL does not reveal the total influence of leg length in walking cost. However, increasing leg length relative to body size before the pubertal spurt would reduce the energetic cost of a wide variety of physical activities.

In summary, an improved and mature gait during subadult phases could have reduced the mortality caused by predators throughout the human evolutionary history. Therefore, the evolutionary pressures that affected human locomotion would have a higher influence during the subadult phases [5] than during adulthood. So, we propose that the same morphological characters that save energy in adults, act also in children, juveniles and early adolescents. The importance of maintaining high levels of physical activity to learn by doing and the development of body segments involved in gait maturation would save energy to be invested in other issues like somatic growth.

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