

# 15<sup>TH</sup> ANNUAL MEETING OF THE EUROPEAN SOCIETY FOR THE STUDY OF HUMAN EVOLUTION ABSTRACTS

## Paris, 25-27 SEPTEMBER 2025

Poster Presentation Number 1, Session 1, Thursday 14:00 - 15:30

### The Jomon genome as a window to exploring potential East Asian adaptations in Vitamin D metabolism and circadian biology

Steven Abood<sup>1</sup>, Koki Yoshida<sup>1</sup>, Hiroki Oota<sup>1</sup>

<sup>1</sup> - University of Tokyo

The ancestors of present-day East Asians journeyed northeast away from Africa's equatorial sun and continued their migration despite standstills lasting approximately 50,000 years, during which their migration was stalled in frigid conditions. A myriad of questions remains about how varying levels of solar ultraviolet irradiation influenced adaptations in Vitamin D metabolism, as well as downstream adaptations related to sleep and circadian chronotypes. To gain insight into these questions, we analyzed 42 ancient genomes from Jomon individuals, prehistoric hunter-gatherers of the Japanese archipelago, along with genomes from modern East Asian populations. Among these, 25 Jomon individuals were newly sequenced in our laboratory by extracting DNA from skeletal remains and performing next-generation sequencing (NGS). These 25 newly analyzed genomes were first reported in our recent preprint [1]. The remaining 17 genomes were obtained from previously published data. All 42 genomes analyzed in this study are identical to those reported in the aforementioned preprint.

We first conducted a literature review to select 26 genes implicated in these adaptations (e.g., PER1, PER2, PER3, CRY1, CRY2, CK1, CLOCK, BMAL1, BMAL2, SIRT1, SIRT6, NPSR1, DHCR7, GC, CYP2R1, CYP27A1, CYP27B1, CYP2J2, VDR, RXR, CYP24A1, CXXC1, LRP5, RUNX2, CYP2J6, and CYP3A4). For each gene, 3 to 6 SNPs (including functional variants) were selected based on previous studies. Databases such as NCBI, gTEX, Ensembl, along with primary literature, were used to determine the functional consequences and allele frequencies of these SNPs in modern populations. These were then compared with allele frequencies in the 42 ancient Jomon genomes. SNPs that displayed significant differences were further examined to gather evidence that adaptations in Vitamin D metabolism, sleep, and circadian chronotypes occurred. Finally, we propose several scenarios that could have resulted in the development of Vitamin D, sleep, and circadian chronotype adaptations with the aim of more fully elucidating the evolutionary history of East Asians.

References: [1] Watanabe, Y., Wakiyama, Y., Waku, D., Valverde, G., Tanino, A., Nakamura, Y., Suzuki, T., Koganebuchi, K., Gakuhari, T., Katsumura, T., Ogawa, M., Toyoda, A., Mizushima, S., Nagaoka, T., Hirata, K., Yoneda, M., Nishimura, T., Izuho, M., Yamada, Y., Masuyama, T., Takahashi, R., Ohashi, J., Oota, H., 2024. Cold adaptation in Upper Paleolithic hunter-gatherers of eastern Eurasia. *bioRxiv*. 2024.05.03.591810.



*PaleoAnthropology* 2025:2: 413–664.

<https://doi.org/10.48738/2025.iss2.4032>

ISSN 1545-0031

Paleoanthropology Society & European Society for the study of Human Evolution.



Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## A strictly modern human trait? Tracing hypoconulid absence in first molars and its evolutionary implications

Majid Aljaber Abo Fakher<sup>1</sup>, Sireen El Zaatari<sup>1</sup>

<sup>1</sup> - Paleoanthropology, Senckenberg Centre for Human Evolution and Palaeoenvironment, Institute of Archaeological Sciences, University of Tübingen, Germany

Due to their hardness, durability, and distinguishing morphology, teeth serve as valuable proxies for tracing evolutionary trajectories in hominin lineages. While, commonly, combinations of dental morphological, non-metric traits are used to characterize and taxonomically classify hominin species, some occurrences of extremely rare traits can, single-handedly, serve as significant indicators for population history, relations, and even species differentiations. Here we focus on one such trait, the hypoconulid absence in the lower first permanent molars. This trait is observable in recent humans, albeit in low overall frequency on a global scale [1]. However, in some recent human populations, particularly modern Eurasians and Northern Africans, the frequency of hypoconulid absence is documented at a relatively much high rate (10%-20%) [1]. Furthermore, the rare documentation of hypoconulid absence in Pleistocene hominin fossils has led to arguments considering it a strictly modern human trait [2]. However, the lack of the hypoconulid in the M1s of *Homo floresiensis* fossils is intriguing. Thus, in this study we retrace the occurrence of this trait in Pleistocene hominins in an attempt to better understand its origin and evolutionary/taxonomic connotations.

For this purpose, we documented the presence/absence of the hypoconulid cusp in a large sample of sufficiently preserved crowns of lower M1s (N=461) dating to the Pleistocene and belonging to different *Homo* species (*Homo sapiens*, Neandertals, Denisovans, *Homo floresiensis*, *Homo naledi*, European and African Middle Pleistocene *Homo*, *Homo erectus/ergaster*, *Homo Habilis*, and Asian *Homo* sp). Scoring of the trait followed [3], where grade 0 equated with the hypoconulid being absent and grades 1-5 indicated its presence. Scoring was conducted primarily on high resolution dental epoxy casts or CT-scans of original specimens (Paleoanthropology collections, University of Tübingen). In cases where neither was available, scoring was done using published occlusal photographs or in few instances, by adopting published scores.

Our findings confirm that with the exception of the two *Homo floresiensis* specimens LB1 and LB6/1 the hypoconulid is present in all pre-Upper Paleolithic hominins we examined. Even in our Upper Paleolithic modern human sample, the hypoconulid is predominantly present and is absent in only a handful of European specimens: the earlier El Castillo C and Kostenki 15, and the later Saint-Germain-de-la-Rivière 1, La Madeleine 4, and Satsurblia SATP5. In contrast, however, we record a much higher frequency of the hypoconulid absence in the relatively few available well-preserved Levantine Upper/Epi-Paleolithic individuals broadly contemporaneous with the Upper Paleolithic in Europe.

The absence of hypoconulid in the LB1 and LB6/1 *Homo floresiensis* lower first molars does not seem to be an effect of size reduction in this species as in the equally small (but older) Mata-Menge individuals' lower first molars the hypoconulid is present. For modern humans, we argue that the absence of the hypoconulid reflects human migrations, replacements, and repopulations. Its notable traceability to some of the earliest Upper Paleolithic individuals outside Africa, the two children from the Levantine site of Ksar Akil (Lebanon), and its documentation in only a few European individuals dating to the mid and late Upper Paleolithic reflect original dispersion of modern humans from the Levant into Europe. Its apparent persistence in the Levant up to the Holocene, along with its high occurrence frequency in recent Europeans reflects the replacement of Upper Paleolithic European populations by new waves of migrations from the Levant.

This research is funded by the European Research Council under the European Union's Horizon 2020 research and innovation program, grant agreement number 101001889 (REVIVE). The REVIVE project is being conducted in close collaboration with the Lebanese Directorate General of Antiquities, Ministry of Culture.

References: [1] Scott, G.R., Turner, C.G., 1997. The Anthropology of Modern Human Teeth: Dental Morphology and its Variation in Recent Human Populations. Cambridge: Cambridge University Press. [2] Bailey, S.E., Tryon, C.A., 2023. The dentition of the early Upper Paleolithic hominins from Ksar 'Akil, Lebanon. *Journal of Human Evolution*. 176, 103323. [3] Turner, C.G., Nichol, C.R., Scott, G.R., 1991. Scoring procedures for key morphological traits of the permanent dentition: the Arizona State University dental anthropology system. In: Kelley, M.A., Larsen, C.S. (Eds.), *Advances in Dental Anthropology*, Wiley-Liss, New York, p. 13–31.

Poster Presentation Number 3, Session 1, Thursday 14:00 - 15:30

## **Be'eri Badlands: early human expansions through the Negev, Israel**

**Nira Alpers-Afil<sup>1</sup>, Onn Crouvi<sup>2</sup>, Gadi Herzlinger<sup>3</sup>, Rivka Rabinovich<sup>4</sup>**

1 - Bar-Ilan University · 2 - Geological Survey of Israel · 3 - Haifa University · 4 - Hebrew University of Jerusalem

The southern part of the Jordan Rift Valley and the Negev desert, at the crossroads of Africa and southwestern Asia, played a significant role in the dispersal of early hominins. Despite its geographical position, very few Lower Palaeolithic sites were discovered and studied in the Negev. The semi-arid northwestern fringe of the Negev contains most of the known Lower Palaeolithic find spots, spanning from the Early to the Middle Pleistocene (e.g. the excavated sites of Bizat Ruhama and Nahal Hesi). Yet most finds were collected by amateurs in sparse assemblages (i.e. handaxes found on the surface) and were not subjected to systematic excavations or in-depth analyses. The limited and fragmented archaeological data from this region resulted in gaps in our understanding of the environment, ecology, chronology, and human presence in the Negev during the Early and Middle Pleistocene.

A new study, at the badlands adjacent to Kibbutz Be'eri in the northwestern Negev, provides compelling evidence of hominin occupation during the Lower and Middle Palaeolithic. The study area is situated within a small drainage basin (~10 km<sup>2</sup>), consisting of numerous small ravines, resulting in a distinct badland topography. These badlands were likely formed during the Early Holocene, and erosional processes continue today, revealing new sections and archaeological artifacts mostly during and after rainfall events. While lithic artifacts, including Acheulian handaxes, have been reported and collected over the years, no formal survey or excavation has taken place in the area. The study involved a systematic survey of several campaigns (2021–2023). More than 2000 lithic artifacts were collected and spatially recorded, some in dense patches and some in sparse scatters. These include a variety of technological categories but consist mostly of unretouched flakes. Indicative artifacts, such as trihedrals, handaxes, biface modification flakes, and Levallois cores and waste, suggest that the area was mostly occupied during the Lower and Middle Palaeolithic. The presence of different lithic categories (including cores, core trimming elements, and microartifacts), suggests that various stages of the lithic reduction sequence were performed. Sedimentological observations and the lithic study indicate that the Be'eri Badlands form part of a broader resource procurement system, where Lower and Middle Palaeolithic hominins occupied various habitats, transported different raw materials, and exploited diverse fauna.

Poster Presentation Number 4, Session 1, Thursday 14:00 - 15:30

## A semi-automated protocol for dental landmarking teeth using the 3D Slicer software

Ana Álvarez-Fernández<sup>1</sup>, Mario Modesto-Mata<sup>1,2</sup>, Arthur Thiebaut<sup>1</sup>, Leslea J. Hlusko<sup>1</sup>

1 - Centro Nacional de Investigación en Evolución Humana (CENIEH), Burgos, Spain · 2 - Universidad Internacional de La Rioja (UNIR), Logroño, La Rioja, Spain

Geometric morphometrics is a well-established and powerful method for statistically analyzing patterns of variation and morphological evolution in biological anthropology and palaeoanthropology (e.g. [1,2]). Despite its effectiveness, one of the main challenges in landmark placement for large sample sizes is the intensely time-consuming nature of the process. To address this challenge, we developed a semi-automated landmarking protocol using the *SlicerMorph*> extension of the *3D Slicer* software. Here, we report on our evaluation of its effectiveness for dental landmark placement. The sample comprises 983 baboon (*Papio anubis*) individuals (females: n=683; males: n=300) with known pedigrees, housed at the Southwest National Primate Research Center (SNPRC, Texas, USA). Both upper and lower dentition were scanned using a high-resolution *Medit i700* intraoral scanner to perform geometric morphometric analyses on the individual teeth and explore dental variation within the population and its implications for quantitative genetics.

The protocol begins with the automatic selection, via the *ALPACA* module, of the 10 individuals of each sex that best represent the overall dental row shape variation within the population —sources—. Eight landmarks are then manually placed on the occlusal surface of each molar, upper and lower, of these source templates. Using the *MALPACA* module, and based on the landmark configurations of the 10 sources, the software generates 11 new .json/.markup files containing landmarks coordinates per individual —targets— (10 based on each source template and one averaged configuration), automatically placing landmarks on each tooth. After reviewing landmark placement in 5% of the total sample, we observed that the averaged configuration did not accurately position the landmarks. Therefore, we opted to use the single source template (rather than the average) that was morphologically closest to each target individual. To identify the most suitable source for each target, we performed a statistical analysis in R software that determined the closest source individual based on morphological similarity determined by the GPA analysis. This approach resulted in somewhat more accurate landmark placement than the averaged configuration.

Landmark placement is a long and tedious process that requires time and concentration. Our results suggest that semi-automated tools such as the *SlicerMorph* extension of *3D Slicer* can partially assist with this task, particularly when working with large samples. The software places landmarks close to their correct anatomical positions, but they then need to be manually adjusted.

This research was funded by the European Research Council within the European Union's Horizon Europe (ERC-2021-ADG, Tied2Teeth, project number 101054659). Support was also provided by the Ministerio de Ciencia e Innovación Project PID2021-122355NB-C33 financed by MCIN/ AEI/10.13039/501100011033/ FEDER, UE. This investigation used resources that were supported by the Southwest National Primate Research Center grant P51 OD011133 from the Office of Research Infrastructure Programs, National Institutes of Health, USA.

References: [1] Bookstein, F.L., 1991. Morphometric Tools for Landmark Data: Geometry and Biology, Cambridge University Press, Cambridge. [2] Slice, D.E., 2005. Modern Morphometrics. In: Slice, D.E., (Ed.), Modern Morphometrics in Physical Anthropology, Springer, New York, p. 1–45.

Poster Presentation Number 5, Session 1, Thursday 14:00 - 15:30

## Recolonizing the Italian Alps after the LGM: seasonal isotopic insights from red deer at Riparo Tagliente (Verona, NE Italy) during the Late Epigravettian

Mahym Amanova<sup>1,2,3,4</sup>, Dorothée Drucker<sup>5,6</sup>, Federica Fontana<sup>7</sup>

1 - Instituto Terra e Memória, Mação, Portugal · 2 - Departamento de História, Artes e Humanidades, Universidade Autónoma de Lisboa, Lisbon, Portugal · 3 - Departamento de Arqueologia, Conservação Restauro e Património, Instituto Politécnico de Tomar, Tomar, Portugal · 4 - CGeo - Centro de Geociências, Universidade de Coimbra, Coimbra, Portugal · 5 - Senckenberg Centre for Human Evolution and Palaeoenvironment, University of Tübingen, Germany · 6 - Department of Geoscience, University of Tübingen, Germany · 7 - Department of Humanities, Unit of Prehistoric and Anthropological Sciences, University of Ferrara, Ferrara, Italy

The end of the Last Glacial Maximum (LGM) marked a critical climatic transition from the cold Greenland Stadial-2 (GS-2) to the abrupt warming of Greenland Interstadial-1 (GI-1), enabling hunter-gatherers to reoccupy high-altitude environments. Riparo Tagliente, a rock shelter in the southeastern Italian pre-Alps, preserves one of the region's most continuous archaeological sequences and documents early Late Epigravettian human re-settlement [1]. Understanding the ecological backdrop of this re-colonization is essential for assessing human subsistence strategies during the Late Glacial climatic fluctuations.

To this end, we analyzed the ecology of a major game species, red deer (*Cervus elaphus*) from Riparo Tagliente, using stable carbon and oxygen isotope ratios ( $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) from sequential samples of second and third molar enamel. The analyzed remains span stratigraphic units 13 to 5 (~16,600-13,400 cal BP), covering the transition from Greenland Stadial-2.1a (GS-2.1a) to Greenland Interstadial-1. Obtained  $\delta^{13}\text{C}$  values indicate a consistent diet based on terrestrial  $\text{C}_3$  plants and suggest the persistence of an open woodland environment across climatic phases. The  $\delta^{18}\text{O}$  values reflect seasonal conditions captured during enamel formation, mainly summer signals from second molars and winter from third molars [2]. Using a linear equation derived in this study, we reconstructed mean monthly air temperatures (MMT) across the studied archaeological layers. The resulting reconstruction indicates the winter MMT in layer 13 reached  $-6.5^\circ\text{C}$  for the period GS-2.1a, when glaciers were melting in the Alpine region. The MMT dropped to  $-8.9^\circ\text{C}$  in winter for layer 10 (GS-2.1a to GI-1 transition), and reached  $9.9^\circ\text{C}$  in summer. During GI-1, summer temperatures peaked at  $15.4^\circ\text{C}$  (layer 9) and  $14.5^\circ\text{C}$  (layer 7), reflecting a pronounced warming trend.

Despite these climatic changes, red deer maintained a stable diet, and the local environment in the southeastern Alpine foreland remained relatively open throughout. These findings underscore the resilience of local ecosystems and their suitability for game species critical to Late Epigravettian subsistence. This likely facilitated the sustained presence, seasonal mobility, and adaptive strategies of hunter-gatherer groups during the Late Glacial, notwithstanding climatic instability.

This research was conducted as part of my Master's thesis. I am deeply grateful to my supervisors, Federica Fontana and Dorothée Drucker, whose guidance, support, and collaboration were essential to the success of this work.

References: [1] Fontana, F., Cilli, C., Cremona, M. G., Giacobini, G., Gurioli, F., Liagre, J., Malerba, G., Rocci Ris, A., Veronese, C., Guerreschi, A., 2009. Recent data on the Late Epigravettian occupation at Riparo Tagliente, Monti Lessini (Grezzana, Verona): a multidisciplinary perspective. *Preistoria Alpina*, 44, pp. 51-60. [2] Stevens, R.E., Balasse, M., O'Connell, T.C., 2011. Intra-tooth oxygen isotope variation in a known population of red deer: Implications for past climate and seasonality reconstructions. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 301, 64-74.

Poster Presentation Number 6, Session 1, Thursday 14:00 - 15:30

## Did the human upright posture shape the cranio-cervical complex?

Mikel Arlegi<sup>1,2</sup>, Aurélien Mounier<sup>1,3,4</sup>, Emma Pomeroy<sup>5</sup>

1 - Histoire Naturelle des Humanités Préhistoriques (HNHP, UMR 7194), PaleoFED, MNHN/CNRS/UPVD, Musée de l'Homme, Paris, France · 2 - McDonald Institute for Archaeological Research, University of Cambridge, UK · 3 - Turkana Basin Institute, Nairobi, Kenya · 4 - CNRS, UAR 3129 – UMIFRE 11 3 Maison Française d'Oxford, Oxford, UK · 5 - Department of Archaeology, University of Cambridge, UK

The human cranio-cervical complex can be readily distinguished from that of other apes by the head's position on a vertical neck. This is accompanied by other morphological traits such as a short face and a rounded cranial vault. The human neck presents a strong lordotic curvature, with vertebrae that are relatively wide and antero-posteriorly short, and which have inferiorly-oriented spinous processes. These differences between humans and other apes have been related to different functional selective pressures – upright posture and bipedalism vs quadrupedalism and knuckle walking/below-branch suspension – acting on human and non-human ape heads and necks [1,2].

Modern humans also differ, albeit to a lesser extent, in posture and morphology from other extinct hominins. For instance, foramen magnum orientation suggests that the degree of cervical lordosis changed during human evolution: australopiths likely displayed a reduced cervical curvature that increased with the emergence of the genus *Homo*, reaching its maximum in modern humans. Moreover, the sparse and fragmentary fossil record reveals marked variation in cervical morphology within *Homo*, and differences that appear to parallel those observed in cranial form. Our hypothesis proposes that different hominin groups, including those from the Neanderthal lineage, “solved” the requirements of erect posture in a different manner.

To answer this question, we assembled three dimensional (3D) virtual models for the cranio cervical region of extant anthropoids, encompassing species that span the full spectrum of habitual postures, locomotor repertoires and body sizes. Landmark data from the 3D models of crania and cervical vertebrae were collected and analysed with Singular Warp analysis to quantify patterns of cranio cervical covariation. The specific influence of habitual head and neck posture was then assessed through redundancy analysis, using posture indices as explanatory variables.

Our results demonstrate that posture exerts a significant effect on cranio cervical integration. *Homo sapiens* presents a covariation pattern that is clearly distinct from those of other hominoids and cercopithecoids, whereas Neanderthals occupy an intermediate yet distinctly human like position, corroborating our previous observations [3,4]. These findings imply that a modern human like configuration of head balance and cervical curvature may have emerged within the genus *Homo* prior to the divergence of Neanderthals and modern humans. Future analyses incorporating African hominin fossils will determine whether this pattern evolved gradually within *Homo* or arose independently in separate lineages, expanding our understanding of the functional and evolutionary pathways that shaped the human head–neck complex.

We extend our sincere gratitude to all curators of the following collections: DL = Duckworth Laboratory, University of Cambridge, Cambridge (UK); MCN = Museu de Ciències Naturals, Barcelona (Spain); PCM = Powell-Cotton Museum, Birchington (United Kingdom); MCZ = Museum of Comparative Zoology, Harvard University, Cambridge, MA (USA); RBINS = Royal Belgian Institute of Natural Sciences, Brussels (Belgium); RMCA = Royal Museum for Central Africa, Tervuren (Belgium); Zool-MNHN = Dept. Zoology, Museum national d'Histoire naturelle, Paris (France); UZ = University of Zurich, Zurich (Switzerland); and NBC = Naturalis Biodiversity Center, Leiden (Netherlands) for their generous access to the skeletal material and their invaluable technical assistance. This research was supported by a British Academy International Fellowship (Ref: IF23\100647) and a Marie-Sklowska-Curie (Project reference: 101108040) awarded to the first author, M. Arlegi, as well as by the grants PID2021-122355NB-C31 and PID2021-122355NB-C32, funded by MCIN/AEI/10.13039/501100011033.

References: [1] Manfrea, E., Mitteroecker, P., Bookstein, F.L., Schaefer, K., 2006. Functional morphology of the first cervical vertebra in humans and nonhuman primates. *The Anatomical Record Part B: The New Anatomist*. 289, 184-194. [2] Nalley, T.K., Grider-Potter, N., 2015. Functional morphology of the primate head and neck. *American Journal of Physical Anthropology*. 156, 531-542. [3] Arlegi, M., 2014. Is the distinct neck morphology of Neandertals related to their cranial shape? An approach using covariation between cranium and cervical vertebrae in Neandertals, modern humans, great apes and Hylobatidae. Master thesis, Muséum national d'Histoire naturelle. [4] Arlegi, M., 2019. Evolutionary study of the cervical region in Hominoidea: Morphology, integration and paleobiological inference. Doctoral thesis, University of the Basque Country & University of Bordeaux. ADDI Institutional Repository. <https://theses.hal.science/tel-02491673>.

Poster Presentation Number 7, Session 1, Thursday 14:00 - 15:30

## Where the dead lie: Neandertal funerary geographies in the Iberian Peninsula

**Andion Arteaga Brieba<sup>1,2</sup>, Cecilia Calvo<sup>1</sup>, Jonas Grabbe<sup>1,3</sup>, Edgar Téllez<sup>1</sup>, Adrián Pablos<sup>4,1</sup>, Ana Pantoja-Pérez<sup>1,5</sup>, Manuel Rodríguez-Almagro<sup>1</sup>, Daniel Rodríguez-Iglesias<sup>1</sup>, Nohemi Sala<sup>1</sup>**

1 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH). Burgos, Spain · 2 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES). Tarragona, Spain · 3 - Universidad de Burgos. Burgos, Spain · 4 - Departamento de Geodinámica, Estratigrafía y Paleontología, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Madrid, Spain · 5 - Centro Mixto UCM-ISCIII de Evolución y Comportamiento Humanos, Madrid, Spain

Funerary behaviour is widely recognised as a defining hallmark of our species. Nevertheless, the origins and transformation of mortuary practices into culturally meaningful expressions remain poorly understood. The prevailing association of funerary behaviour with formal burials may have obscured earlier and more subtle manifestations of these practices. Recent interpretations suggest that such behaviours may have emerged during the Middle Pleistocene, among Neandertals and their immediate ancestors, as early expressions of a “culture of death”. Addressing this possibility requires a shift in perspective. Rather than focusing solely on formal burials, it calls for the integration of taphonomic and spatial approaches to assess the potential intentionality behind the accumulation of human remains.

In this context, the Iberian Peninsula offers a particularly informative record for exploring the development of early funerary behaviour. Its marked geographic and ecological diversity resulted in a wide range of habitats and adaptive scenarios throughout the Pleistocene. Furthermore, the region is particularly rich in Middle Palaeolithic archaeological sites that attest to a sustained Neandertal presence, alongside numerous localities preserving Neandertal and pre-Neandertal fossil remains. Importantly, Iberia is recognised as a major refugium for Neandertal populations during MIS 3, providing a valuable framework for tracing the long-term development and variability of funerary practices.

We present a comprehensive review of all known Iberian sites that have yielded fossil remains of Neandertals and their Middle Pleistocene ancestors, spanning from MIS 12 to MIS 3. The dataset includes information on the Number of Identified Specimens (NISP), Minimum Number of Individuals (MNI), site chronology, archaeological context, and, where available, interpretations regarding the origin of the accumulation. In total, 50 archaeological units from 46 sites have been documented and integrated into an open-access database. This dataset provides a robust framework for reassessing the presence and variability of funerary behaviour in the region.

To date, no formal burials have been identified in the Iberian Peninsula. However, this absence does not preclude the existence of funerary practices. At several sites—such as Sima de los Huesos, Sima de las Palomas, and potentially Cova Negra—repeated and systematic accumulations of human remains in specific locations may reflect intentional deposition. These patterns are consistent with the concept of funerary caching (*sensu* [1]). Concurrently, the region also includes two sites—El Sidrón and Zafarraya—where taphonomic evidence indicates that the accumulation of human remains resulted from episodes of cannibalism [2-3]. The motivations behind these practices may vary, ranging from nutritional to social or symbolic reasons. However, their role in death-related behaviours suggests that they should not be excluded from broader discussions on funerary variability.

Despite the fragmentary nature of the Iberian fossil record and the relative paucity of detailed contextual analyses, the available evidence points to an early emergence of funerary behaviour in the region. This is expressed through the recurrent accumulation of human bodies in non-modified spaces over time, once natural processes such as carnivore activity have been ruled out. These patterns underscore the need to move beyond restrictive definitions of burial practices and to recognise a broader spectrum of mortuary behaviours as part of early human culture of death.

This research has received funding from the European Research Council under the European Union's Horizon 2020 research and innovation program (Grant agreement No. 949330) and PID2021-122355NB-C31 and PID2021-122355NB-C33 funded by MCIN/AEI/10.13039/501100011033/FEDER, UE. NS and AP have received funding from the Ministerio de Ciencia e Innovación under the Ramón y Cajal program (RYC2020-029656-I and RYC2023-045715-I, respectively), funded by MCIN/AEI/10.13039/501100011033 and El FSE invierte en tu futuro.

References: [1] Pettitt, P., 2011. The Palaeolithic origins of human burial, Routledge, New York. [2] Barroso Ruiz, C., de Lumley, H., 2006. La grotte du Boquete de Zafarraya, Málaga, Andalousie, Junta de Andalucía. Consejería de Cultura. [3] Rosas, A., Martínez-Maza, C., Bastir, M., García-Tabernero, A., Lalueza-Fox, C., Huguet, R., Ortiz, J.E., Julià, R., Soler, V., de Torres, T., Martínez, E., Cañaveras, J.C., Sánchez-Moral, S., Cuezva, S., Lario, J., Santamaría, D., de la Rasilla, M., Fortea, J., 2006. Paleobiology and comparative morphology of a late Neandertal sample from El Sidrón, Asturias, Spain. Proceedings of the National Academy of Sciences. 103, 19266–19271.

Poster Presentation Number 8, Session 1, Thursday 14:00 - 15:30

## New palaeoproteomic insights into Kleine Feldhofer Grotte, Germany

Ragnheiður Diljá Ásmundsdóttir<sup>1</sup>, Leire Torres-Iglesias<sup>1</sup>, Michael Wierer<sup>2</sup>, Ralf W. Schmitz<sup>3</sup>, Frido Welker<sup>1</sup>

1 - Globe Institute, Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark · 2 - Proteomics Research Infrastructure, University of Copenhagen, Copenhagen, Denmark · 3 - LVR-LandesMuseum Bonn, Department of Prehistory, Bonn, Germany

A large part of the archaeological record are bone fragments that are too small for species identification based on morphology. Two palaeoproteomic applications have been developed to tackle this problem, Zooarchaeology by Mass Spectrometry (ZooMS) [1], which utilises peptide mass fingerprinting (PMF) of collagen type 1 through MALDI-ToF MS, and Species by Proteome INvestigation (SPIN) [2], which utilises LC-MS/MS analysis to identify single amino acid polymorphisms (SAAP) in numerous proteins present within the SPIN database. Sample selection strategies for these two palaeoproteomic applications are generally based on sample availability. A recent study of Early Holocene faunal remains has shown that cortical bone outperformed its trabecular bone counterpart for both ZooMS identification and overall proteome preservation [3].

Here we present new proteomic insights of 52 previously unstudied bone fragments from the Kleine Feldhofer Grotte. These fragments were recovered during excavations conducted in 1997 and 2000, and which resulted in the discovery of additional Neanderthal fragments belonging to the Neanderthal type specimen [4]. The Kleine Feldhofer Grotte is located in the Neander Valley in Germany, where the type specimen of Neanderthals was discovered in 1856. Over the past 30 years efforts have been made to analyse the fragmented bone assemblage discovered at the site, in attempts to discover further Neanderthal evidence [5]. The bone fragments analysed here include specimens consisting of only one bone tissue type, either cortical or trabecular bone, as well as eight specimens containing both cortical and trabecular bone, to further study the potential differences of cortical and trabecular bone, as well as to study the identifications from the two applications.

The ZooMS analysis allowed for species identification, to at least group level, for 72.9% of specimens, while SPIN allowed for identification of 86.5% of the specimens. Thirteen specimens were identified as *Homo* sp. through ZooMS. An additional two specimens, who were unidentifiable in ZooMS, were identified as *Homo* sp. through the SPIN application. Additional research is needed to establish whether these potential Neanderthal bone fragments belong to the already established individuals from Kleine Feldhofer Grotte or if they represent new individuals. The remaining identified specimens were identified as horses, woolly rhinoceros, mammoths, cervids, and carnivores.

For eight specimens both cortical and trabecular bone were sampled. Species identification was possible for seven out of eight of the specimens. No large observable difference was found between cortical and trabecular bone for either analytical method in terms of the number of identified peptide markers, in ZooMS, or the number of amino acid site counts, in SPIN. However, we observe differences in peptide abundance and the level of protein modification between cortical and trabecular bone pairs. This indicates that although proteins are relatively well-preserved in the bone specimens recovered from the Kleine Feldhofer Grotte, sampling decisions involving Late Pleistocene material should consider preferring cortical bone when aiming to maximise full proteome identification.

This study has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No 948365).

References: [1] Buckley, M., Collins, M., Thomas-Oates, J., Wilson, J.C., 2009. Species identification by analysis of bone collagen using matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry. *Rapid Communications in Mass Spectrometry*. 23, 3843–3854. [2] Rütger, P.L., Husic, I.M., Bangsgaard, P., Gregersen, K.M., Pantmann, P., Carvalho, M., Godinho, R.M., Friedl, L., Cascalheira, J., Taurozzi, A.J., Jørgov, M.L.S., Benedetti, M.M., Haws, J., Bicho, N., Welker, F., Cappellini, E., Olsen, J.V., 2022. SPIN enables high throughput species identification of archaeological bone by proteomics. *Nature Communications*. 13. [3] Ásmundsdóttir, R.D., Hansen, J., Fagerås, Z., Troché, G., Olsen, J.V., Saña Seguí, M., Welker, F., 2024. Early Holocene preservation differences between cortical and trabecular bone proteomes. *Journal of Archaeological Science: Reports*. 57, 104643. [4] Schmitz, R.W., Serre, D., Bonani, G., Feine, S., Hillgruber, F., Krainitzki, H., Pääbo, S., Smith, F.H., 2002. The Neanderthal type site revisited: Interdisciplinary investigations of skeletal remains from the Neander Valley, Germany. *Proceedings of the National Academy of Sciences*. 99, 13342–13347. [5] Lanigan, L.T., Mackie, M., Feine, S., Hublin, J.-J., Schmitz, R.W., Wilcke, A., Collins, M.J., Cappellini, E., Olsen, J.V., Taurozzi, A.J., Welker, F., 2020. Multi-protease analysis of Pleistocene bone proteomes. *Journal of Proteomics*. 228, 103889.

Poster Presentation Number 9, Session 1, Thursday 14:00 - 15:30

## Miocene ape locomotor diversity: a 3D geometric morphometric analysis of fore- and hindlimb joints

Juliet Azé<sup>1</sup>, Marta Mirazón-Lahr<sup>1</sup>, John Rowan<sup>1</sup>

<sup>1</sup> - Department of Archaeology, University of Cambridge

One of the major challenges in paleoanthropology is reconstructing the locomotor behavior of the last common ancestor of hominins and *Pan*. In the absence of early fossils of *Pan* and *Gorilla*, the evolution of both knuckle-walking and bipedalism remains contentious. In this paper, we use proximal femur and distal humerus joint morphology to build a predictive model of locomotor behavior of extant primates and use this model to explore potential locomotion patterns in a group of Miocene fossil apes.

We used 3D geometric morphometrics to quantify the shape of living primate and fossil ape joint morphology to see how living primates with distinct locomotor behaviors differed and how fossil apes fit into those patterns. Landmarks on the proximal femora (n=13) and distal humeri (n=18) of the living and fossil sample were taken and adjusted using a generalized Procrustes analysis (GPA). Principal component and thin-plate spline analyses were used to visualize the morphospace of these skeletal features in the sample of living and fossil specimens, and linear discriminant analysis (LDA) was used to assess the probability of inferring locomotor patterns of the Miocene fossil species on the basis of extant diversity.

Results show that variation in the shape of the proximal femur in living species captures the differences in locomotor behaviors. The fossil apes fall in an intermediate part of the morphospace and do not align with the living taxa locomotor clusters. This agrees with previous analyses that show that much of Miocene ape postcranial morphology lacks direct analogs among extant species. The *Nacholapithecus* proximal femur falls closer to arboreal quadrupeds, despite some previous findings showing morphology similar to that of *Equatorius*, believed to be more terrestrial. Fossil apes that others have suggested to be highly suspensory and similar in ways to living apes (e.g., *Hispanopithecus*) also fall in an intermediate portion of the morphospace.

These preliminary results are interesting and further suggest that locomotor differences among living primates fit the pattern of variation in the shape of this functionally important joint. The fossil femora occupy an intermediate position between the monkey-like and ape-like shape. Some of the fossils, however, align more closely with certain living primates, indicating that some of the Miocene ape species studied had hip joints that functioned in a manner that was similar to locomotor modes seen today. Preliminary results on the distal humeral joint throw further light on the complexity of interpreting the functional morphology of Miocene apes.

This project contributes to the field by exploring the shape of two key joints that have not been extensively studied across a large sample of fossil apes and adds to the growing evidence for locomotor diversity among early apes. Altogether, our results emphasize that the morphological variation among Miocene apes has important implications for inferring their behavior, as well as for shaping models of the last common ancestor between *Pan* and hominins.

I am grateful to my mentors, Dr. John Rowan and Prof. Mirazón-Lahr for their guidance and support through the stages of this project. Many thanks also to Dr. Julia Aramendi for her direction regarding the 3D geometric morphometric landmark analysis method. We also want to thank the Department of Archaeology, specifically the Paleoanthropology laboratory and the Duckworth laboratory at the University of Cambridge for providing the necessary resources and facilities to conduct this research.

Podium Presentation, Session 3, Thursday 16:00 – 17:40

## Brain development and evolution at the base of *Homo erectus*: insights from the Drimolen juvenile

Karen L. Baab<sup>1</sup>, Jesse M. Martin<sup>2,3</sup>, Gary T. Schwartz<sup>4</sup>, Allison Nesbitt<sup>4,5</sup>, A.B. Leece<sup>3</sup>, Stephanie E. Baker<sup>6</sup>, Andy I.R. Herries<sup>3,6</sup>, David S. Strait<sup>6,9</sup>

1 - Department of Anatomy, Midwestern University, Glendale, AZ, USA · 2 - Leverhulme Centre for Human Evolutionary Studies, Department of Archaeology, University of Cambridge, Cambridge, United Kingdom · 3 - Palaeoscience, Dept. Archaeology and History, La Trobe University, Bundoora Campus, Naarm, VIC, Australia · 4 - Institute of Human Origins, School of Human Evolution and Social Change, Arizona State University, AZ, USA · 5 - Department of Pathology & Anatomical Sciences, University of Missouri, MO, USA · 6 - Palaeo-Research Institute, Bunting Road Campus, Auckland Park, University of Johannesburg, Gauteng, South Africa · 7 - Department of Anthropology, Washington University, St. Louis, MO, USA

There is broad agreement that dental, skeletal and brain development do not follow a strictly modern human-like course in *Homo erectus*, with significant implications for cognition, behavior and life history. However, there are conflicting interpretations of certain aspects of brain growth in *H. erectus* due in part to the small number of juvenile *H. erectus* fossils. New data from the DNH 134 juvenile calvaria from Drimolen, South Africa (~2.0 Ma) may inform our understanding of brain growth and development. This fossil was assigned to *H. erectus* based on traditional *H. erectus* qualitative traits (e.g., midline frontal keeling, low squamosal suture, angled occipital bone) while the thin cranial bones and unfused cranial sutures suggest a young age at death, perhaps 2-3 years [1]. Here we consider the developmental context for the brain size of DNH 134 using a comparative sample of extant chimpanzees, modern humans and Pleistocene *Homo*.

The estimated endocranial volume (EV) of 538 cm<sup>3</sup> for DNH 134 implies an EV (and brain weight) below the range for 2-3 year-old modern humans. In contrast, the Mojokerto brain weight is within the lower bounds of comparably aged modern humans [2]. Workers have suggested that an increased rate of brain size growth was a shared derived feature of *H. erectus* and *H. sapiens*, but this may not have characterized the earliest part of the *H. erectus* lineage. Instead, the Drimolen evidence hints at evolution of brain growth rates within the *H. erectus* lineage after 2.0 Ma. There is, however, evidence for prolonged brain growth in this early population. Compared to the average EV of adult African *H. erectus* >1.5 Ma, DNH 134 reached a proportional EV (pEV) within the modern human range, and lower than expected based on the chimpanzee pattern. If the adult population at Drimolen was more like that from Dmanisi, the pEV for DNH 134 is still closer to the human pattern but within the range of values for chimpanzees, too. Previous studies on Mojokerto came to conflicting conclusions, with different analyses supporting a chimp-like pEV [3] or a unique pattern of proportional growth somewhat intermediate between humans and chimpanzees [4]. While this analysis is sensitive to assumptions about adult brain size of the population that included DNH 134, the findings presented here are more compatible with the latter interpretation. Taken together, these results imply that despite a more human-like pattern of proportional brain growth, the rate of absolute brain growth is distinctly non-modern in early Pleistocene *Homo* at Drimolen. This latter observation is consistent with other indicators (e.g., M1 emergence) for a more ape-like life history profile for early *Homo* [5] with further implications for energetics and the emergence of secondary altriciality.

We thank the joint La Trobe University (LTU) and University of Johannesburg, Drimolen Palaeoanthropology Field School students for their work in recovering fossils from Drimolen. We thank D. Smith, J. Smith, and K. Nkosi, the landowners at Drimolen who granted our permission to work at the site, in conjunction with the South African Heritage Resources Agency (SAHRA), and B. Zipfel for facilitating access to the hominin collections at the University of the Witwatersrand. The bulk of this research was funded by Australian Research Council Future Fellowship Grant FT120100399 and ARC Discovery Grant DP170100056.

References: [1] Herries, A.I.R., Martin, J.M., Leece, A.B., Adams, J.W., Boschian, G., Joannes-Boyau, R., Edwards, T.R., Mallett, T., Massey, J., Murszewski, A., Neubauer, S., Pickering, R., Strait, D.S., Armstrong, B.J., Baker, S., Caruana, M.V., Denham, T., Hellstrom, J., Moggi-Cecchi, J., Mokobane, S., Penzo-Kajewski, P., Rovinsky, D.S., Schwartz, G.T., Stammers, R.C., Wilson, C., Woodhead, J., Menter, C., 2020. Contemporaneity of *Australopithecus*, *Paranthropus*, and early *Homo erectus* in South Africa. *Science*. 368. [2] Leigh, S.R., 2006. Brain ontogeny and life history in *Homo erectus*. *Journal of Human Evolution*. 50, 104–108. [3] Coqueugniot, H., Hublin, J.-J., Veillon, F., Houët, F., Jacob, T., 2004. Early brain growth in *Homo erectus* and implications for cognitive ability. *Nature*. 431, 299–302. [4] O'Connell, C.A., DeSilva, J.M., 2013. Mojokerto revisited: Evidence for an intermediate pattern of brain growth in *Homo erectus*. *Journal of Human Evolution*. 65, 156–161. [5] Schwartz, G.T., 2012. Growth, development, and life history throughout the evolution of *Homo*. *Current Anthropology*. 53, S395–S408.

Poster Presentation Number 10, Session 1, Thursday 14:00 - 15:30

## Character displacement in the dental arcade of sympatric capuchin monkeys

Katharine L. Balolia<sup>1,2</sup>, Kris Kovarovic<sup>2</sup>

1 - School of Archaeology and Anthropology, Australian National University, Canberra, Australia · 2 - Department of Anthropology, Durham University, Durham, UK

Capuchin monkeys are represented by gracile and robust species that often live sympatrically, and robust capuchins show derived features related to processing hard and tough foods [1]. Research that seeks to investigate the selective pressures related to character displacement for skeletal and dental traits associated with dietary niche divergence among capuchin species has the potential to afford further insights about the underlying basis for morphological variation observed within the cebinae. Such findings will also provide a useful comparative context to better understand interspecific variation among extinct hominin taxa.

In the research presented here, we investigated whether gracile and robust capuchin species living in sympatric zones show character displacement in regions of the anterior and postcanine dental arcade. We collected 3D landmark data taken from surface models of 137 cranial specimens of dentally mature individuals representing *Cebus albifrons*, *C. olivaceus* and *C. apella*. These species were selected for investigation because *C. albifrons* and *C. olivaceus* are sympatric with *C. apella* in some areas of their geographic range. Approximately 50% of the sample for each species was obtained from geographic regions where gracile and robust species live sympatrically, and the remaining sample was obtained from non-sympatric zones. We used 3D geometric morphometric methods to quantify incisor row shape and postcanine row shape, using landmarks taken from the alveolar margin of both dental regions.

Our initial findings show that in geographical regions in which gracile and robust capuchin species overlap, all three species (*C. albifrons*, *C. olivaceus* and *C. apella*) show character displacement in regions of the dental arcade. *Cebus albifrons* in sympatric regions have a flatter incisor row and show medial rotation of the second incisor. *Cebus albifrons* and *C. olivaceus* in sympatric regions have a relatively long postcanine row, and *C. apella* in sympatric regions have a relatively wide postcanine row. We discuss our findings of character displacement in sympatric capuchin populations in the context of the hard tissue adaptations for dietary specialisations associated with niche divergence observed in sympatric hominin species, including *Homo* spp. and *Paranthropus* spp. [2,3].

References: [1] Lynch-Alfaro, J.W., Silva Jr, J.D.S.E., Rylands, A.B., 2012. How different are robust and gracile capuchin monkeys? An argument for the use of *Sapajus* and *Cebus*. *American Journal of Primatology*. 74, 273-286. [2] Schroer, K., Wood, B., 2015. The role of character displacement in the molarization of hominin mandibular premolars. *Evolution*. 69, 1630-1642. [3] Uluutku, A.S., 2024. The role of character displacement and ecological niche incumbency in hominin evolution. Doctoral Dissertation, The George Washington University.

Podium Presentation, Session 3, Thursday 16:00 – 17:40

### The brain of *Homo neanderthalensis*

**Antoine Balzeau<sup>1,2</sup>, Éric Bardin<sup>3</sup>, Ameline Bardo<sup>1</sup>, Anne-Laure Bernat<sup>1</sup>, Mélanie Didier<sup>3</sup>, Andréa Filippo<sup>1</sup>, Emmanuel Gilissen<sup>2,4</sup>, Victor Giolland<sup>1</sup>, Asier Gómez-Olivencia<sup>5</sup>, Aida Gomez Robles<sup>6</sup>, Yann Heuzé<sup>7</sup>, Jean-Jacques Hublin<sup>8</sup>, Jiaming Hui<sup>9</sup>, Anna Maria Kubicka<sup>10</sup>, Nicole Labra<sup>1,11</sup>, Yann Leprince<sup>12</sup>, Jean-François Mangin<sup>12</sup>, Shelly Masi<sup>13</sup>, Emmanuelle Pouydebat<sup>14</sup>, Sylvain Prima<sup>1,15</sup>, Denis Rivière<sup>12</sup>, Nohemi Sala<sup>16</sup>, Mathieu D. Santin<sup>3</sup>, Romain Valabré<sup>3</sup>, Christine Verna<sup>1</sup>, Mónica Villalba de Alvarado<sup>1,17</sup>, Patricia Wils<sup>18</sup>, Aurélien Mounier<sup>1,19,20</sup>**

1 - PaleoFED team, UMR 7194 Histoire Naturelle des humanités Préhistoriques, MNHN-CNRS-UPVD, Paris, France · 2 - Department of African Zoology, Royal Museum for Central Africa, Tervuren, Belgium · 3 - ICM-Institut du Cerveau, Hôpital Pitié-Salpêtrière, Centre de NeuroImagerie de Recherche-CENIR, Paris, France · 4 - Université Libre de Bruxelles, Alzheimer and other tauopathies research group, ULB Center for Diabetes Research (UCDR), Brussels, Belgium · 5 - Department Geología, Facultad de Ciencia y Tecnología, Universidad del País Vasco-Euskal Herriko Unibertsitatea (UPV/EHU), Leioa, Spain · 6 - Department of Anthropology, University College London, London, UK · 7 - Univ. Bordeaux, CNRS, Ministère de la Culture, PACEA, UMR 5199, Pessac, France · 8 - Chaire de Paléanthropologie, Collège de France, 75005 Paris, France · 9 - Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences · 10 - Department of Zoology, Poznań University of Life Sciences, Poznań, Poland · 11 - Centre for Advance Research Computing (ARC), University College London (UCL) · 12 - Université Paris-Saclay, CEA, CNRS UMR 9027, Baobab, NeuroSpin, Gif-sur-Yvette, France · 13 - UMR 7206 Éco-Anthropologie, MNHN-CNRS, Paris, France · 14 - UMR 7179 Mécanismes adaptatifs et évolution, MNHN-CNRS, Paris, France · 15 - Inria Rennes, France · 16 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Burgos, Spain · 17 - Universidad del País Vasco-Euskal Herriko Unibertsitatea (UPV/EHU), Donostia, Spain · 18 - UAR 2700 Acquisition et Analyse de Données pour l'Histoire naturelle, MNHN-CNRS, Paris, France · 19 - Turkana Basin Institute, Nairobi, Kenya · 20 - CNRS, UAR 3129 UMIFRE 11 3 Maison Française d'Oxford, Oxford, UK

Palaeoneurology is fascinating but a highly debated field, mostly because the brain does not fossilise. Our only way to learn from this organ in fossil specimens is hidden inside the skull: the imprints on the inner surface of the bone that can be molded into what we call the endocast. This proxy, the only available evidence to study brain evolution, has been widely used historically to infer the evolutionary history of the hominin brain. More specifically, the question of the evolution of the brain of prehistoric humans has been addressed in the past by analyzing either specific brain structures [1] or the entire endocranial surface [2]. One study also proposed a reconstruction of a Neandertal brain by deforming virtually a current brain into a Neandertal skull [3]. An obvious limiting factor in the field is the lack of robust scientific data documenting the detailed relationship between the brain's sulci and the fine imprints visible on the inner surface of the skull [4].

In this context, we have investigated for the first time the correlation between the shape of the brain and that of the endocast within a sample of 75 living humans using MRI acquisitions, which included some specific acquisitions with a particular sequence (ultrashort time to echo, UTE) allowing better characterisation of bone tissues than conventional sequences like T1 or T2-weighted. Our main objective was to exploit this unique dataset to provide an objective reading key for the endocast. This involved establishing the correspondence between the sulci visible on each brain and all the visible imprints on the endocast of each subject. We described and quantified the link between these different structures to provide objective elements for our understanding and interpretation of all the information visible on an endocast. We conducted an original and integrative study, combining anthropological, neuroanatomical and human sciences. Complementary tools were used to reconstruct all 3D models. We then created an anatomical atlas of visible marks on endocasts, compiling the imprints due to the presence of a sulcus as well as the numerous ones that are not linked to cerebral anatomy. This original knowledge has been applied to investigate the individual characteristics of key fossil specimens to try to assess their brain characteristics in a more objective way than proposed before.

We have compiled a large comparative material of human fossils to carry out a particular study of the cerebral characteristics of Neandertals. The methods employed included comparative anatomy, multivariate analyses of measurements defined on real brain areas and a diffeomorphic approach to compare the differential extension of the lobes between the different groups. It appears in our newly proposed model that the brain of *Homo neanderthalensis* is not simply an enlarged version of the brain of *Homo erectus*, even if both align along the same allometric trajectory [2]. It is also characterised by unique patterns, including frontal lobes extended backward, wide occipital lobes and an expansion of the posterior-inferior part of the temporal and parietal lobes.

Finally, we applied our newly proposed endocast reading key to the description of the detailed morphology of the endocast of key fossil specimens, in order to reconstruct the brains of these specimens. To do this, we used the available data on the skull-endocast relationship within our current sample to transform the endocast models into brain reconstructions that consider the actual individual characteristics of the specimens. This is how we can present for the first time a reconstruction of a Neandertal brain showing the cerebral characteristics of this species.

This research received funding from the Agence National de la Recherche (ANR-20-CE27-0009).

References: [1] Ponce de León, M.S., Bienvenu, T., Marom, A., Engel, S., Tafforeau, P., Alatorre Warren, J.L., Lordkipanidze, D., Kurniawan, I., Murti, D.B., Suriyanto, R.A., Koesbardiati, T., Zollikofer, C.P.E., 2021. The primitive brain of early *Homo*. *Science*. 372, 165–171. [2] Neubauer, S., Hublin, J.-J., Gunz, P., 2018. The evolution of modern human brain shape. *Science Advances*. 4. [3] Kochiyama, T., Ogihara, N., Tanabe, H.C., Kondo, O., Amano, H., Hasegawa, K., Suzuki, H., Ponce de León, M.S., Zollikofer, C.P.E., Bastir, M., Stringer, C., Sadato, N., Akazawa, T., 2018. Reconstructing the Neanderthal brain using computational anatomy. *Scientific Reports*. 8. [4] Labra, N., Mounier, A., Leprince, Y., Rivière, D., Didier, M., Bardinet, E., Santin, M.D., Mangin, J.F., Filippo, A., Albessard-Ball, L., Beaudet, A., Broadfield, D., Bruner, E., Carlson, K.J., Cofran, Z., Falk, D., Gilissen, E., Gómez-Robles, A., Neubauer, S., Pearson, A., Rösing, C., Zhang, Y., Balzeau, A., 2023. What do brain endocasts tell us? A comparative analysis of the accuracy of sulcal identification by experts and perspectives in palaeoanthropology. *Journal of Anatomy*. 244, 274–296.

Poster Presentation Number 11, Session 1, Thursday 14:00 - 15:30

## Multi-isotope analysis of mammalian fauna from the Middle Pleistocene (MIS 6) Lazaret Cave: palaeoecological, palaeoenvironmental and archaeological implications

Sarah Barakat<sup>1</sup>, Kennedy Williams<sup>1</sup>, Malte Willmes<sup>2</sup>, Emmanuel Desclaux<sup>3,4</sup>, Kate Britton<sup>1</sup>

1 - Department of Archaeology, University of Aberdeen, Aberdeen, United Kingdom · 2 - Norwegian Institute for Nature Research, Trondheim, Norway · 3 - Laboratoire de Préhistoire du Lazaret, Département des Alpes-Maritimes, Nice, France · 4 - CEPAM – UMR 7264 CNRS - UCA, Nice, France

Rich in archaeological and palaeoecological evidence, cave and rock shelters are extraordinary sources of potential information about the Pleistocene which can help us reconstruct past climate, environment, and human and animal ecology. In this study we explore possible changes in dietary and movement ecology of mammalian fauna from the Middle Pleistocene (MIS 6) Lazaret Cave, France, to infer broader palaeoenvironmental conditions of a classic southern glacial refugia. Tooth enamel from red deer (*Cervus elaphus*), ibex (*Capra ibex*), aurochs (*Bos primigenius*), and grey wolves (*Canis lupus*) found within Lazaret Cave Complex C, was sampled for carbon ( $\delta^{13}\text{C}$ ), oxygen ( $\delta^{18}\text{O}$ ) and strontium ( $^{87}\text{Sr}/^{86}\text{Sr}$ ) isotopic analysis. Isotopic results were then divided between the three subcomplexes (CII inf., CII sup., and CIII) which make up Complex C to see how habitat, dietary niches and landscape use changed through time during Neanderthal occupations.

Results show a C3 dominated landscape made up of mixed open woodlands, and more open steppe like environments throughout the Neanderthal occupations at Lazaret Cave.  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  data demonstrate consistent differences in isotopic niche space between the carnivore and herbivores, and amongst the different ungulate species, which are largely consistent with the results of previous dental microwear studies [1]. Oxygen isotope data from red deer were also used to reconstruct mean annual temperature (MAT) throughout the different subcomplexes. The MAT is consistently lower than today showing cooler climates in this southern glacial refugia during MIS 6. These reconstructed temperatures broadly fit with other temperature reconstructions found at MIS 6 archaeological and palaeoecological sites found across France but are relatively elevated compared to climate proxy data from natural (i.e. non-anthropogenic) archives at the site [2]. This may be due to Neanderthal activity at Lazaret Cave being predominantly restricted to more ameliorate periods of MIS 6. Finally, strontium isotope data from red deer and ibex demonstrate use of lithologically-varied montane and coastal areas within approximately 50km of the site. Their habitat ranges largely overlap, aside from during CII sup., which also has the warmest MAT reconstruction, where a spatial partitioning can be observed. The results from this study have broader implications for understanding Middle Pleistocene faunal palaeoecology, palaeoenvironments, and hominin activity at Lazaret Cave, in the context of a classic southern glacial refugia.

This research is part of the collective research project named "Paleoecology of the Lazaret Cave: human-environment interactions on the coast of the meridional Alps during the late Middle Pleistocene (MIS6)," granted by the DRAC PACA (French Ministry of Culture) and Département des Alpes-Maritimes and led by Emmanuel Desclaux.

References: [1] Rivals, F., Cohen, J., Desclaux, E., 2023. Dietary traits of the ungulates from the Middle Pleistocene sequence of Lazaret Cave: palaeoecological and archaeological implications. *Archaeological and Anthropological Sciences*. 15. [2] López-García, J.M., Blain, H.-A., Sánchez-Bandera, C., Cohen, J., Lebreton, L., Montuire, S., Stewart, J.R., Desclaux, E., 2021. Multi-method approach using small vertebrate assemblages to reconstruct the Marine Isotope Stage 6 climate and environment of the Lazaret cave sequence (Maritime Alps, Nice, France). *Palaeogeography, Palaeoclimatology, Palaeoecology*. 577, 110529.

Poster Presentation Number 12, Session 1, Thursday 14:00 - 15:30

## Cortical bone asymmetry in La Ferrassie Neandertals and modern human thumbs reveals occupational stress patterns

Ameline Bardo<sup>1,2</sup>, Jules Brunaud<sup>1</sup>, Arnaud Delapré<sup>3</sup>, Samar M. Syeda<sup>2,4,5</sup>, Gerhard Hotz<sup>6,7</sup>, Fotios Alexandros Karakostis<sup>7,8,9</sup>

1 - UMR 7194 - HNHP, CNRS-MNHN, Département Homme et Environnement, Musée de l'Homme, Paris, France · 2 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 3 - UMR 7205 - ISYEB, CNRS/MNHN/UPMC/EPHE, Paris, France · 4 - Richard Gilder Graduate School, American Museum of Natural History, NY, USA · 5 - Division of Anthropology, American Museum of Natural History, NY, USA · 6- Anthropological collection, Natural History Museum of Basel, Basel, Switzerland · 7 - Integrative Prehistory and Archaeological Science, University of Basel, Basel, Switzerland · 8 - DFG Centre for Advanced Studies “Words, Bones, Genes, Tools: Tracking linguistic, cultural and biological trajectories of the human past”, Institute of Archaeological Sciences, University of Tübingen, Tübingen, Germany · 9 - Paleoanthropology, Senckenberg Centre for Human Evolution and Palaeoenvironment, Department of Geosciences, Eberhard Karls University of Tübingen, Tübingen, Germany

The transformation of our environment is facilitated by the use of our hands. This interaction, guided by muscular coordination, was crucial during the Paleolithic period for the creation of the first lithic tools, which transformed hominin strategies for resource exploitation. Bones, as living tissues, have the ability to adapt their shape in response to different physical constraints [1]. In this context, the internal structure of metacarpals offers valuable insights into hominin behavioural patterns and can help reconstruct their evolutionary history. In this study, we aim to test the hypothesis that Neanderthal first metacarpals exhibit bilateral asymmetry—an idea supported by archaeological evidence associated with these individuals [2]. We also investigate whether the structure of cortical bone reflects signatures of precise manipulation, a skill essential for lithic tool production.

Using microCT data, we analysed the right and left first metacarpals (MC1) of the La Ferrassie Neanderthals 1 and 2 (42–47 ka), as well as of modern *Homo sapiens*, to identify bilateral asymmetry and activity-related markers in cortical bone architecture. Our modern human sample includes individuals with well-documented biological profiles and occupational histories [3,4], providing a comparative framework for interpreting the Neanderthal data.

Using the morphomap package in R [5], we examined the effects of bilateral asymmetry on average cortical bone thickness and the polar moment of inertia (J). Different patterns of bilateral asymmetry were observed along various parts of the diaphysis when analyzing average cortical thickness across occupational groups. We found pronounced right-side dominance in the area corresponding to the insertion of the opponens pollicis muscle in individuals engaged in fine, precise manual tasks. In contrast, those involved in forceful precision tasks exhibited right-side dominance at the opponens pollicis insertion site and left-side dominance at the abductor pollicis insertion site. Individuals performing heavy manual labour displayed high variability. When assessing J, men engaged in precision work had a more mechanically resistant right MC1, whereas male heavy labourers showed greater resistance in the left MC1. Women exhibited similar bilateral asymmetry patterns, except for J in the proximal diaphysis: women with specialized occupations had a more resistant right MC1, while those with unspecialized tasks had a more resistant left MC1.

Finally, we observed sexual dimorphism between LF1 (male) and LF2 (female), with LF1 exhibiting greater cortical thickness and rigidity. Each individual also showed different directional asymmetry: right-side bias in LF1 and left-side bias in LF2. LF1 followed a pattern similar to that of precision workers, while LF2 resembled the pattern of heavy manual labourers, suggesting that the thumbs of these two Neanderthals were subjected to different mechanical stresses. This study lays the foundation for future research into the relationship between functional constraints and bilateral asymmetry in hand bones.

We are thankful to all volunteers of the “Citizen Science Basel” (University of Basel) and the staff of the City Hall Archive Basel-Stadt for access to biographical information. Thanks to Dominique Grimaud-Hervé for giving us access to the micro-CT scans of La Ferrassie 1 and thanks to the AST-RX platform (UAR 2700 2AD CNRS-MNHN, Paris) for producing the micro-CT scans of La Ferrassie 2, made possible by funding from European Union's Horizon 2020 research and innovation program Grant #819960 (Matthew M. Skinner). Thanks to Georg Schulz, Scientific and Technical Manager of the Micro- and Nanotomography Platform (MiNa), for performing the microCT scans of the modern material. This project was funded in part by the “MetaSym” project (AAP MNHN Paris, A. Bardo).

References: [1] Ruff, C., Holt, B., Trinkaus, E., 2006. Who's afraid of the big bad Wolff? “Wolff's law” and bone functional adaptation. *American Journal of Physical Anthropology*. 129, 484–498. [2] Uomini, N.T., Ruck, L., 2018. Manual laterality and cognition through evolution: An archeological perspective. *Progress in Brain Research*. 238, 295–323. [3] Hotz, G., Steinke, H., 2012. Knochen, Skelette, Krankengeschichten. Spitalfriedhof und Spitalarchiv - zwei sich ergänzende Quellen. *Basler Zeitschrift für Geschichte und Altertumskunde*. 112, 105–138. [4] Karakostis, F.A., Hotz, G. 2022. Reflections of manual labor in the hand entheses of early industrial women workers with extensively documented life histories. *American Journal of Biological Anthropology*. 183, e24636. [5] Profico, A., Bondioli, L., Raia, P., O'Higgins, P., Marchi, D., 2020. morphomap: An R package for long bone landmarking, cortical thickness, and cross-sectional geometry mapping. *American Journal of Physical Anthropology*. 174, 129–139.

Poster Presentation Number 13, Session 1, Thursday 14:00 - 15:30

## **μCT internal traceology: fresh or dry? A case study of Mousterian bone retouchers**

**Malvina Baumann<sup>1,2</sup>, Nicolas Vanderesse<sup>3</sup>, Serge Maury<sup>4</sup>, Sylvain Renou<sup>3,5</sup>, Hugues Plisson<sup>3</sup>, Svetlana Shnaider<sup>2</sup>, Kseniya Kolobova<sup>6</sup>, William Rendu<sup>2</sup>**

1 - TraceoLab, Liege University, Liege, Belgium · 2 - ZooStan, International Research Laboratory 2033, CNRS, Al-Farabi Kazakh National University, Almaty Kazakhstan · 3 - PACEA UMR 5199, CNRS, University of Bordeaux, Pessac, France · 4 - Les Eyzies-de-Tayac, France · 5 - Hadès, Agence Atlantique, Bordeaux, France · 6 - Institute of Archaeology and Ethnography, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russian Federation

Traceological analysis (sensu S.A. Semenov [1]) applied to Neanderthal bone tools faces two major challenges. Firstly, these artefacts are only slightly shaped, produced by a limited range of techniques, with percussion prevailing. As such, the analysis relies on discrete traces for which existing frame of reference are poorly suited. Secondly, due to their organic nature and age, these artefacts are likely to have been altered by a wide range of taphonomic agents. To compensate for the loss of surface information, we propose developing a method of internal traceology based on the specific properties of bone tissue [2].

Bone is both an organic and mineral material that displays transverse isotropic behavior at the macrostructural level. Depending on the stresses it experiences, it can record deformations or fissures that affect its internal structure in complex but predictable ways. This internal damage has the potential to reveal the nature of the mechanical constraints applied to the artefact during its manufacture and use [3]. Furthermore, bone as a raw material evolves over time. After the animal dies, it gradually loses its organic component, which changes its mechanical properties and thus its response to stress. Since the “freshness” of the bone influences the characteristics of internal damage, such damage may provide insights into the condition of the bone at the time it was manufactured or used.

Extending traceological analysis to internal damage requires the use of additional observation techniques. Today, microtomography is among the most widely used imaging techniques for examining internal structure of bone tissue. This non-destructive analysis involves acquiring a series of X-ray radiographs over 360°. These images are then combined following the principles of Computerized Tomography to produce a volumetric model of the artefact, which can be explored in three dimensions at micrometric resolution [4].

In this study, we illustrate the potential of this method through the example of the bone retoucher. Bone retoucher is the most frequently encountered bone tool in Neanderthal assemblages. Typically made from a fragment of long bone diaphysis, it was used as a light hammer for shaping and maintaining lithic edges [5]. With a well-defined and widely accepted function, the bone retoucher provides an ideal case study for examining correlations between external use-wear and internal damage.

On the basis of a collection of archaeological bone retouchers from the Quina Mousterian levels at the site of Chez-Pinaud-Jonzac (Charente-maritime, France), along with an experimental set of both “fresh” and “dry” bone retouchers, we show that internal damage can be a diagnostic markers of the tool’s technical status. It provides information about how the tool was used and the freshness of the bone. Internal traceology thus open a new avenue for investigating Neanderthal practices in the management and exploitation of animal resources.

References: [1] Semenov, S.A., 1964. Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear, Cory, Adams & Mackay, London. [2] Baumann, M., Plisson, H., Rendu, W., Maury, S., Kolobova, K., Krivosheina, A., 2020. The Neanderthal bone industry at Chagyrskaya cave, Altai Region, Russia. *Quaternary International*. 559, 68–88. [3] Backwell, L., Bradfield, J., Carlson, K.J., Jashashvili, T., Wadley, L., d’Errico, F., 2018. The antiquity of bow-and-arrow technology: evidence from Middle Stone Age layers at Sibudu Cave. *Antiquity*. 92, 289–303. [4] Davis, G.R., Wong, F.S.L. 1996. X-ray microtomography of bones and teeth. *Physiological Measurement*. 17, 121. [5] Mallye, J.-B., Thiébaud, C., Mourre, V., Costamagno, S., Claud, E., Weisbecker, P., 2012. The Mousterian bone retouchers of Noisetier Cave: experimentation and identification of marks. *Journal of Archaeological Science*. 39, 1131–1142.

Podium Presentation, Session 6, Friday 16:00 – 17:40

## New Neandertal remains from Sirogne Cave (Lot, France): implications for human evolution and behavior prior to the last interglacial

Priscilla Bayle<sup>1</sup>, Benjamin Albouy<sup>2</sup>, Mathilde Augoyard<sup>1</sup>, Vincent Balter<sup>3</sup>, Marlon Bas<sup>4,5</sup>, Cédric Beauval<sup>6</sup>, Maryelle Bessou<sup>1</sup>, Mathieu Bosq<sup>1</sup>, Laurent Bruxelles<sup>7</sup>, Thomas Colard<sup>1</sup>, Isabelle Crevecoeur<sup>1</sup>, Pierre-Jean Dodat<sup>8</sup>, Pauline Ehrhardt<sup>9</sup>, Jean-Philippe Faivre<sup>1</sup>, Christophe Falguères<sup>10</sup>, Guillaume Guérin<sup>11</sup>, François Lacrampe-Cuyaubère<sup>6</sup>, Christelle Lahaye<sup>12</sup>, Adeline Le Cabec<sup>1</sup>, Mona Le Luyer<sup>1</sup>, Arnaud Lenoble<sup>1</sup>, Stéphane Madelaine<sup>13</sup>, Bruno Maureille<sup>1</sup>, Xavier Muth<sup>14</sup>, Cosimo Posth<sup>15</sup>, Maïlys Richard<sup>12</sup>, Hélène Rougier<sup>16</sup>, Aurélien Royer<sup>17</sup>, Colette Sirieix<sup>18</sup>, Luca Sitzia<sup>19</sup>, Adrien Thibeault<sup>1</sup>, Alain Turq<sup>13</sup>, Clément Zanolli<sup>1</sup>

1 – Univ. Bordeaux, CNRS, Ministère de la Culture, PACEA, UMR 5199, Pessac, France · 2 – Département d'Anthropologie, Univ. Montréal, Montréal, Canada · 3 – ENS Lyon, CNRS, Univ. Lyon 1, LGL-TPE, UMR 5276, Lyon, France · 4 – Austrian Archaeological Institute, Austrian Academy of Sciences, Vienna, Austria · 5 – Center for Forensic Medicine, Medical University of Vienna, Vienna, Austria · 6 – Archéosphère SARL, Quillan, France · 7 – Univ. Toulouse Jean Jaurès, CNRS, TRACES, UMR 5608, Toulouse, France · 8 – OD Earth and History of Life, Royal Belgian Institute of Natural Sciences, Brussels, Belgium · 9 – Muséum national d'Histoire naturelle, CNRS, Éco-anthropologie, UMR 7206, Paris, France · 10 – Muséum national d'Histoire naturelle, CNRS, HNHP, UMR 7194, Paris, France · 11 – Univ. Rennes, CNRS, Géosciences Rennes, UMR 6118, Rennes, France · 12 – Univ. Bordeaux Montaigne, CNRS, Université de Bordeaux, EPHE-PSL, Archéosciences Bordeaux, UMR 6034 CNRS, Pessac, France · 13 – Musée national de Préhistoire, Les Eyzies, France · 14 – Get in Situ, Bourg-en-Lavaux, Switzerland · 15 – Archaeo- and Palaeogenetics, Institute for Archaeological Sciences, Department of Geosciences, University of Tübingen, Tübingen, Germany · 16 – Department of Anthropology, California State University Northridge, Northridge, USA · 17 – Université Bourgogne Europe, CNRS, Biogéosciences UMR 6282, Dijon, France · 18 – Univ. Bordeaux, CNRS, Arts et Métiers Institute of Technology, Bordeaux INP, INRAE, I2M Bordeaux, Talence, France · 19 – Departamento de Antropología, Universidad de Tarapacá, Arica, Chile

While neighboring regions have yielded numerous Neandertal remains, few discoveries have been reported from the limestone plateaus of the Quercy region in France [1]. However, the accidental discovery in 2006 of a Neandertal-like hemimandible and a deciduous tooth by a speleologist in Sirogne Cave — located within a Jurassic karst system in the northern part of the Alzou Canyon near Rocamadour (Lot, France) — prompted six excavation seasons between 2013 and 2018. These aimed to better understand the chronology, modes of Neandertal occupation, and biological evolution of the populations using the site.

The excavations clarified the context of the 2006 discovery and revealed a partially disturbed stratigraphy, affected by recent human interventions. Nevertheless, several preserved layers, covered by stalagmitic floors along the western wall of the cave, were identified. Most notably, nearly 100 human fossils were unearthed from the cave, representing at least 10 individuals: Three children (aged 3–8 years), two adolescents, three young adults, and two older adults. The remains include two hemimandibles (one immature, one adult), over 80 isolated teeth, and infracranial elements. Although most come from sediments affected by post-depositional processes, all exhibit unambiguous Neandertal features. Several infracranial bones show cut marks indicative of dismemberment and disarticulation, suggesting complex mortuary behaviors. The reworked layers also contained faunal remains from over 20 taxa, reflecting a broad but clearly Pleistocene spectrum resulting from both natural and anthropogenic accumulations. More than 2,000 lithic artefacts in quartz, flint, and limestone were also recovered, pointing to at least two Paleolithic techno-complexes: one attributed to the Middle Paleolithic and another to the end of the Last Glacial Maximum.

Moreover, Sirogne may correspond to the “Crozo del Dua” cave excavated in the early 20th century by André Niederlander, which yielded five isolated Neandertal teeth and a lithic assemblage [1-3]. Our reanalysis of his faunal collection led to the identification of two additional Neandertal remains — a phalanx and a lower permanent canine — morphologically consistent with the Sirogne material.

Combined geological, taphonomic, biochronological, and absolute dating of the stalagmitic floors and associated sediments place the Neandertal fossils within Marine Isotope Stage (MIS) 6, most probably at the end of the Middle Pleistocene (ca. 150,000–130,000 years ago), which represents a critical, yet poorly documented, phase in Neandertal evolutionary history [4].

Morphometric analyses of the teeth and mandibles suggest that the Sirogne individuals are more closely aligned with early Neandertals (pre-MIS 5) than with later groups. They exhibit classic Neandertal features and share affinities with Middle Pleistocene fossils based on external dental dimensions, enamel-dentine junction (EDJ) shape, and non-metric dental traits. Additionally, the low inter-individual variation in EDJ morphology indicates significant biological homogeneity within the Sirogne group. This homogeneity appears even greater than that observed at the Krapina MIS 5e site (Croatia), possibly reflecting regional isolation during MIS 6. Altogether, this exceptional assemblage offers rare and crucial insights into

population dynamics and evolutionary processes during a key period in Neandertal history. The evidence supports a model of strong group structuring and complex demographic patterns in Europe prior to 120,000 years ago [4].

Further analyses are currently underway, including attempts at ancient DNA extraction, calcium isotope studies for dietary reconstruction, and SR-microCT imaging of dental microstructures to explore growth patterns and developmental stress. A new three-year excavation project will further refine the chronocultural context and clarify the processes underlying the accumulation of human remains at the site.

We acknowledge the following institutions for their support: Direction régionale des Affaires Culturelles and Service régional de l'Archéologie Occitanie, Musée national de Préhistoire Les Eyzies, Conseil général du Lot, association Archéologies, Archéosphère SARL. We particularly thank Didier and Isabelle Baudet, and Guy Bariviera for their help during the field work. This research was also supported by the Ministère de l'Enseignement supérieur et de la Recherche, the CNRS, the "Investments for the Future" program IdEx Bordeaux (3Dent'in project, ANR-10-IDEX-03-02; STEP ITAP project, OPE-2018-0181), and the Région Nouvelle-Aquitaine through the NATCH and ADNER projects (2016-1R40204, and AAPR2021-2020-11779310). This research benefited from the scientific framework of the University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past".

References: [1] Genet-Varcin, E., 1966. Etude de dents permanentes provenant du gisement moustérien de la Croze del Dua (Lot). *Annales de Paléontologie Vertébrés*. LII, 89-114. [2] Niederlander, A., 1951. La Préhistoire dans la région de Gramat. *Bulletin de la Société des études du Lot*. LXXII, 162-167. [3] Turq, A., 2000. Historique des recherches régionales. *Paléo. suppl.* 2000, 18-21. [4] Peyrégne, S., Slon, V., Mafessoni, F., de Filippo, C., Hajdinjak, M., Nagel, S., Nickel, B., Essel, E., Le Cabec, A., Wehrberger, K., Conard, N.J., Kind, C.J., Posth, C., Krause, J., Abrams, G., Bonjean, D., Di Modica, K., Toussaint, M., Kelso, J., Meyer, M., Pääbo, S., Prüfer, K., 2019. Nuclear DNA from two early Neandertals reveals 80,000 years of genetic continuity in Europe. *Science Advances*. 5, eaaw5873.

Podium Presentation, Session 10, Saturday 15:50 – 17:10

## A century after the Taung child: new insights into the evolutionary history of *Australopithecus*

Amélie Beaudet<sup>1,2,3</sup>, Dominic Stratford<sup>3,4</sup>, Maryke Horn<sup>3</sup>, Harmony Hill<sup>1</sup>, Edwin de Jager<sup>2</sup>, Charlotte Theye<sup>1,5</sup>

1 - Laboratoire de Paléontologie, Évolution, Paléoécosystèmes et Paléoprimatologie (PALEVOPRIM), UMR 7262 CNRS & Université de Poitiers, France · 2 - Department of Archaeology, University of Cambridge, United Kingdom · 3 - School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, South Africa · 4 - Department of Anthropology, Stony Brook University, Stony Brook, New York, USA · 5 - Department of Anatomy, University of Pretoria, South Africa

A century after the discovery and publication of the Taung child, the hypodigm of *Australopithecus africanus* has expanded considerably. Hundreds of hominin specimens attributed to the genus *Australopithecus*, ranging from well-preserved crania (e.g., Sts 5) to partial skeletons (e.g., Sts 14, StW 431, StW 573), have been recovered from the Sterkfontein Caves. Notably, the *Australopithecus* assemblage from Sterkfontein displays a high degree of morphological variation. While some researchers interpret this as intraspecific variation within *Australopithecus africanus*, others have suggested the presence of a second, more *Paranthropus*-like species, *Australopithecus prometheus* [1]. A third possibility, explored in this study, is that this variation pattern reflects diachronic changes within a single, evolving lineage [2-3]. As part of the ANR-funded LHOSA project, we test the hypothesis of an anagenetically evolving lineage at Sterkfontein by developing a morpho-spatial analysis of the *Australopithecus* remains.

We investigated *Australopithecus* specimens from Member 2, Member 4 and Jacovec Cavern (N=18) scanned at the University of the Witwatersrand and at the Necsa South African Nuclear Energy Corporation (Necsa) in South Africa. Characters were selected based on their anatomical preservation and their potential to capture polymorphism, including cranial (face, vault, base, endocranial) and postcranial (vertebral) features. Clusters of specimens were determined by a combination of character-states that include morphological (e.g., inner ear morphology), textural (e.g. vertebral bone density), structural (e.g., cranial vault tissue organisation), geometrical (e.g., brain imprints) and dimensional (e.g., carotid canal size) criteria.

Besides confirming the presence of variation patterns in the axial skeleton of *Australopithecus* throughout the depositional sequence of Sterkfontein, our preliminary results identify at least two distinct clusters of *Australopithecus* specimens. One is characterised by a typical *Australopithecus*-like suite of characters with similarities to eastern African specimens, and another exhibiting a mosaic of traits traditionally associated with *Paranthropus* and *Homo*. Some specimens, such as the enigmatic StW 53, remain outliers.

We do not reject the hypothesis of a single lineage exhibiting gradual morphological change. However, spatial analyses will be critical to test whether character-state distributions correlate with stratigraphic depth. Extending this integrative approach to other African localities, especially those with temporally constrained sequences [3-4], will be essential for further testing anagenetic models and deepening our understanding of hominin evolutionary mechanisms.

This research project is financially supported by the Agence Nationale de la Recherche (ANR-24-CE02-2903), the Centre National de Recherche Scientifique (CPJ-Hominines), the Fondation Fyssen, the University of Cambridge HDPS, and the National Research of South Africa (#129336).

References: [1] Clarke, R.J., Pickering, T.R., Heaton, J.L., Kuman, K., 2021. The earliest South African hominids. *Annual Review of Anthropology*. 50, 125-143. [2] Beaudet, A., 2023. The *Australopithecus* assemblage from Sterkfontein Member 4 (South Africa) and the concept of variation in palaeontology. *Evolutionary Anthropology: Issues, News, and Reviews*. 32, 154–168. [3] Kimbel, W.H., Lockwood, C.A., Ward, C.V., Leakey, M., Rak, Y., Johanson, D., 2006. Was *Australopithecus anamensis* ancestral to *A. afarensis*? A case of anagenesis in the hominin fossil record. *Journal of Human Evolution*. 51, 134–152. [4] Boissier, J.-R., Guy, F., Delagnes, A., Hlukso, L.J., Bibi, F., Beyene, Y., Guillemot, C., 2008. New palaeoanthropological research in the Plio-Pleistocene Omo Group, Lower Omo Valley, SNNPR (Southern Nations, Nationalities and People Regions), Ethiopia. *Comptes Rendus Palevol*. 7, 429-439.

Poster Presentation Number 14, Session 1, Thursday 14:00 - 15:30

## 15,000-year-old human skull-cups from Courbet Cave (France)

Silvia M. Bello<sup>1</sup>, William A. Marsh<sup>1</sup>, Selina Brace<sup>1</sup>, Ian Barnes<sup>1</sup>, Simon Parfitt<sup>1,2</sup>

1 - Centre for Human Evolutionary Research, Natural History Museum, London (UK) · 2 - University College London, London (UK)

The Magdalenian (~23.5 – ~13.5 kBP) is one of the two major technocomplexes identified in Europe during the late Upper Palaeolithic and is notable for its complex artistic and ritualistic representations. Magdalenian human assemblages are mainly represented by scattered and fragmented remains showing evidence of post-mortem manipulation that has been associated with funerary cannibalism [1]. Cranial fragments are often over-represented at cannibalistic sites, and the post-mortem manipulation of the cranial vaults associated with the manufacture of skull-cups has been observed at five sites: Le Placard and Isturitz in France; El Castillo Cave in Spain; Gough's Cave in the UK; and Brillenhöhle in Germany [2].

Here we present new evidence of modified human remains from the site of Courbet cave (France). Courbet cave, also known as Roc du Courbet or Caverne de Bruniquel, is a cave site on the east side of the Aveyron river near Montauban in southwestern France (44° 03' N, 1° 40' E). The cave was initially explored and excavated by amateurs on multiple occasions during the 18th century before the owner of the cave the Visconte de Lastic Saint-Jal discovered and collected an outstanding assemblage of lithics and osseous remains including exceptional Upper Palaeolithic engraved objects, which were acquired by the British Museum (London, UK) in 1864 [3]. Recent studies on the over 1300 artefacts from the cave attribute material to both the Middle and Upper Magdalenian periods, with barbed points, antler rods, spear throwers and artistically engraved bones, as well as two artefacts made of whale bone [4].

Radiocarbon dating of this material suggests a Middle to Upper Magdalenian origin. Human remains have been directly dated to between 15,401 and 14,975 calBP (OxA-31628) and between 13,495 and 13,248 calBP (OxA-31626). Both dates are towards the latter half of the Magdalenian, with the younger material dating to the late Upper Magdalenian to Azilian transition.

The human collection is composed of over 50 human fragments, representing a MNI of 6 individuals: a perinatal, a 2–3-year-old infant, at least three adults and one older individual. All human remains, which are exclusively represented by cranial fragments regardless of the individual's age, show anthropic modifications in the form of cut marks and percussion damage. At least two adult skulls have modifications consistent with their shaping into skull-cups [2], and two mandibles were purposefully broken along the angle of the mandible, a pattern consistent with the extraction of marrow.

We interpret this assemblage as the result of ritualistic manipulation of human bodies, with the modification, collection, and possible special treatment of heads/skulls. Although the modifications of two mandibles may be suggestive of cannibalism, the absence of postcranial remains makes this attribution tentative. Nevertheless, the presence of a further site with evidence of manipulation of human remains beyond the cannibalistic act is suggestive of the maintenance within the Magdalenian culture of a funerary behaviour rich in ritualistic meanings which spread across north-western Europe over a relatively short period of time.

The study of the Courbet Cave human assemblage is part of the 'Magdalenian People' project, funded by the Calleva Foundation.

References: [1] Marsh, W.A., Bello, S., 2023. Cannibalism and burial in the late Upper Palaeolithic: Combining archaeological and genetic evidence. *Quaternary Science Review*. 319, 108309. [2] Marginedas, F., Rodríguez-Hidalgo, A., Soto, M., Bello, S.M., Cáceres, I., Huguet, R., Saladié, P., 2020. Making skull cups: butchering traces on cannibalised human skulls from five European archaeological sites. *Journal of Archaeological Science*, 114, 105076. [3] Cook, J., Welté, A.-C., 1995. La grotte du Courbet (Tarn): sa contribution dans l'histoire de l'homme fossile et de l'art paléolithique. *Bulletin de la Société Préhistorique Ariège-Pyrénées*. 50, 85-96. [4] Lucas, C., Cook, J., Pétilon, J.-M., Megrath, K., van der Sluis, L., Cartwright, C., Ladier, E., Grubert, M., 2023. Industry and art on osseous materials from Courbet cave (Penne, Tarn, France) in the British Museum collections: evidence of Magdalenian connections. *Industrie et art sur matières osseuses de la grotte du Courbet (Penne, Tarn, France) au British Museum: témoins de contacts magdaléniens*. *Bulletin de la Société Préhistorique Française*. 120, 135-160.

Podium Presentation, Session 9, Saturday 14:00 – 15:20

## Madura Strait, the first subsea *Homo erectus* site in Sundaland (Indonesia)

Harold W.K. Berghuis<sup>1,2</sup>, Iwan Kurniawan<sup>3</sup>, Yousuke Kaifu<sup>4</sup>, Unggul Prasetyo Wibowo<sup>5</sup>, Thijs van Kolfschoten<sup>1,6</sup>, Indra Sutisna<sup>7</sup>, Shinatria Adhityatama<sup>8</sup>, Sofwan Noerwidi<sup>7</sup>, Gert van den Bergh<sup>9</sup>, Eduard Pop<sup>1,10</sup>, Rusyad Adi Suriyanto<sup>11</sup>, Ivo Verheijen<sup>12</sup>, Alice Versendaal<sup>13</sup>, Tony Reimann<sup>14</sup>, A. Veldkamp<sup>15</sup>, Josephine C.A. Joordens<sup>1,10,16</sup>

1 - Faculty of Archaeology, Leiden University, Leiden, The Netherlands · 2 - Sealand Coastal Consultancy, Amsterdam, The Netherlands · 3 - Center for Geological Survey of Indonesia, Bandung, Indonesia · 4 - The University Museum, The University of Tokyo, Tokyo, Japan · 5 - Geological Museum, Bandung, Indonesia · 6 - Joint International Research Laboratory of Environmental and Social Archaeology, Shandong University, Qingdao; Institute of Cultural Heritage, Shandong University, Shandong, China · 7 - Badan Riset dan Inovasi Nasional, Organisasi Riset Arkeologi, Bahasa dan Sastra, Jl. Condet Pejaten No.4, Jakarta, Indonesia · 8 - Griffith Centre for Social and Cultural Research, Griffith University, Gold Coast, QLD, Australia · 9 - School of Earth, Atmospheric and Life Sciences, University of Wollongong, Australia · 10 - Naturalis biodiversity Center, Leiden, The Netherlands · 11 - Laboratory of Bioanthropology and Paleoanthropology, Universitas Gadjah Mada, Jl. Bulaksumur, Yogyakarta, Daerah Istimewa Yogyakarta, Indonesia · 12 - University of Tübingen, Senckenberg Gesellschaft für Naturforschung, Tübingen, Germany · 13 - Soil Geography and Landscape Group & Netherlands Centre for Luminescence Dating, Wageningen University, Wageningen, The Netherlands · 14 - Geomorphology & Geochronology Group, Institute for Geography, University of Cologne, Köln, Germany · 15 - Faculty ITC, University of Twente, Enschede, The Netherlands · 16 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

Eastern Asia has yielded a rich fossil record of Pleistocene hominins, ranging from *Homo erectus* and the diminutive island species *Homo floresiensis* and *Homo luzonensis*, to post-erectus grade late archaic *Homo* (including Denisovans), and finally to anatomically modern humans. The now submerged Sunda Shelf played an important role in the dispersal and evolution of hominin populations. The shelf has been widely exposed during most of the Pleistocene, forming a landmass known as Sundaland. Today, the area holds the world's largest shelf sea. Thus far, hominin fossils from submerged Sundaland were not available. Here we report on the discovery of a rich vertebrate fossil fauna, including two hominin cranial fragments, from the submerged Sunda Shelf. During a dredging work in the Madura Strait off the Java coast, fossiliferous sand was retrieved for land reclamation and used to create an artificial island in the Surabaya port. The vertebrate fossils in this material—accidentally discovered on the island surface—originally derive from the sandy fill of a late Middle Pleistocene submerged valley of the Solo River, that was OSL dated to ~146-131 ka [1]. The faunal assemblage comprises at least 36 species and consists of fluvial, estuarine and terrestrial taxa, providing a unique insight into the lowland fauna of Sundaland during the late Middle Pleistocene [2]. The lowland river had a rich reptile community comprising turtles, crocodilians, varanids, and pythons. The nearby estuary was frequented by sharks, including the extinct *Hemipristis serra*, and stingrays. The surrounding plains were populated by herbivores such as Hippopotamidae and several species of Bovidae, Cervidae, and Proboscidea. The terrestrial community is similar to the contemporaneous fossil assemblage of Ngandong (Java) but includes also *Duboisia santeng*, *Axis hydekkeri*, and *Epileptobos groeneveldtii*. The distributional context and taphonomy of the fossils indicate that the remains of the terrestrial and fluvial species form a homogeneous assemblage, which may derive from a single death event or from steady, seasonal supply of animal remains to the river [3]. Most of these fossils were later concentrated in a marine lag deposit, which overlies the fluvial strata and is associated with the MIS 5 transgression. The fossils of estuarine species derive from the estuarine strata that overlie this marine lag and are linked to the stage of peak-highstand conditions around MIS 5e (~123 ka). The bone remains of the terrestrial species have been subject to two fracturing stages: a green-state fracturing stage prior to fluvial uptake and a sub-fossil-state fracturing stage during later marine reworking. Extensive green-state fragmentation of ruminant limb bones is a result of hominin bone battering and marrow processing. The age-at-death frequency distribution of bovids suggests selective hunting of prime adult prey. Cut marks on turtle bones show that the local hominins also fed on these aquatic species [3]. The hominin cranial fossils consist of a frontal fragment and a parietal fragment, called Madura Strait 1 and 2 respectively [4]. Metric and morphological comparisons with Pleistocene skulls from the Asian mainland, Java and Flores point to a relation with the late *Homo erectus* of Java, notably with the crania from Sambungmacan. The Madura Strait hominins were probably part of an MIS 6 population that lived along the lowland part of the Solo River, which in this period continued eastward over the exposed shelf area of the Madura Strait. In the late Middle Pleistocene climate setting that was relatively dry especially during glacial, the large perennial rivers and coastal areas of Sundaland must have offered attractive living conditions for *H. erectus*.

This study was carried out with permission of the Indonesian Ministry of Research, Technology and Higher Education (RISTEK research permits: 263/SIP/FRP/ES/Dit. KI/VII/2016 of Josephine Joordens; 284/SIP/FRP/ES/Dit.KI/IX/2018 and 343/E5/E5.4/SIP/2019 of Harold Berghuis) under the project 'Studying Human Origin in East Java', and under the agreement between the Center for Geological Survey, Bandung, and The University Museum of the University of Tokyo. The CT scan in Japan was conducted under the research permits issued from BRIN, 631/SIP/IV/FR/7/2024 for Y.K. and 634/SIP/IV/FR/7/2024 for H.B, with the JSPS KAKENHI (Grant number 23K17404) for Y.K. We thank the dredging contractor PT Van Oord Indonesia and Sealand Consultancy for their cooperation and kind provision of background data of the dredging work. We also thank the port operator PT Pelindo III for their support, logistic assistance and admittance to the port site. Most

of all, we thank the owner and developer of the land reclamation, PT Berlian Manyar Sejahtera (BMS) for their permission, cooperation and hospitality. We also thank the Geological Museum in Bandung for its great contributions and hospitality. The study was funded by the Faculty of Archaeology, Leiden University and the Dutch Research Council NWO (Grant number 016.Vidi.171.049 to J.C.A.J.).

References: [1] Berghuis, H.W.K., Veldkamp, A., Adhityatama, S., Reimann, T., Versendaal, A., Kurniawan, I., Pop, E.L., van Kolfschoten, T., Joordens, J.C.A., In press. A late Middle Pleistocene lowstand valley of the Solo River on the Madura Strait seabed, geology and age of the first hominin locality of submerged Sundaland. *Quaternary Environments and Humans*. [2] Berghuis, H.W.K., van den Bergh, G., van Kolfschoten, T., Prasetyo Wibowo, U., Kurniawan, I., Adhityatama, S., Sutisna, I., Verheijen, I., Pop, E.L., Veldkamp, A., Joordens, J.C.A., In press. First vertebrate faunal record from submerged Sundaland: the late Middle Pleistocene, hominin-bearing fauna of the Madura Strait. *Quaternary Environments and Humans*. [3] Berghuis, H.W.K., van Kolfschoten, T., Prasetyo Wibowo, U., Kurniawan, I., Adhityatama, S., Sutisna, I., Pop, E.L., Veldkamp, A., Joordens, J.C.A., In press. The taphonomy of the Madura Strait fossil assemblage, a record of selective hunting and marrow processing by late Middle Pleistocene Sundaland hominins. *Quaternary Environments and Humans*. [4] Berghuis, H.W.K., Kaifu, Y., Prasetyo Wibowo, U., van Kolfschoten, T., Sutisna, I., Adhityatama, S., Noerwidi, S., van den Bergh, G., Pop, E.L., Suriyanto, R., Veldkamp, A., Joordens, J.C.A., Kurniawan, I., In press. The late Middle Pleistocene *Homo erectus* of the Madura Strait, first hominin fossils from submerged Sundaland. *Quaternary Environments and Humans*.

Poster Presentation Number 15, Session 1, Thursday 14:00 - 15:30

## An international research network on bipedalism

Gilles Berillon<sup>1</sup>, Jérémy Duveau<sup>1,2,3</sup>, Quentin Cosnefroy<sup>4</sup>, Peter Aerts<sup>5,6</sup>, Valentina Agostini<sup>7</sup>, Amélie Beaudet<sup>8,9,10</sup>, Lia Betti<sup>11</sup>, Alicia Blasi-Toccaceli<sup>12</sup>, Paul Boursin<sup>13</sup>, Jaroslav Bruzek<sup>4,14</sup>, Cécile Callou<sup>15</sup>, Marine Cazenave<sup>16,17,18</sup>, Tara Chapman<sup>19,20</sup>, Tony Chevalier<sup>1</sup>, Lloyd A. Courtenay<sup>4</sup>, Christine Couture-Veschambre<sup>4</sup>, Kris d'Août<sup>21</sup>, Guillaume Daver<sup>8</sup>, François Druelle<sup>22</sup>, Barbara Fischer<sup>23,24</sup>, Pierre Frémondrière<sup>22</sup>, Marco Ghisleri<sup>25</sup>, Dominique Grimaud-Hervé<sup>1</sup>, Nicole D. S. Grunstra<sup>23,26</sup>, Franck Guy<sup>8</sup>, Martin Haeusler<sup>27</sup>, Anthony Herrel<sup>28</sup>, Franck Lamberton<sup>29</sup>, Mathilde Lequin<sup>4</sup>, Victoria A. Lockwood<sup>8</sup>, Chloé Martin<sup>15</sup>, Philipp Mitteroecker<sup>24,28</sup>, Franck Multon<sup>30</sup>, Zoé Nowicki<sup>8</sup>, Laurent Pallas<sup>1</sup>, Antoine Perrier<sup>31,32</sup>, Amira Perrot<sup>1</sup>, Victoria Poltze<sup>27</sup>, Rebeka Rmoutilova<sup>14</sup>, Karen R. Rosenberg<sup>33</sup>, Ekaterina Stansfield<sup>23</sup>, Pierre Tessier<sup>34</sup>, Lionel Tholon<sup>35</sup>, Nicole Torres-Tamayo<sup>11,27</sup>, Benjamin Tournan<sup>27</sup>, Bruno Watier<sup>36</sup>, Laura M. Watson<sup>37</sup>, Nicole Webb<sup>27,37</sup>, Ashleigh L. Wiseman<sup>11,38</sup>, François Marchal<sup>23</sup>

1 - UMR7194 HNHP, CNRS-MNHN-UPVD, France · 2 - Paleoanthropology, Institute for Archaeological Sciences, Eberhard Karls Univ. of Tübingen, Germany · 3 - DFG Center for Advanced Studies, Eberhard Karls Univ. of Tübingen, Germany · 4 - UMR5199 PACEA, Univ. de Bordeaux-CNRS-Ministère de la Culture, Pessac, France · 5 - Department of Biology, Functional Morphology Laboratory, Univ. of Antwerp, Belgium · 6 - Department of Movement and Sports Sciences, Univ. of Ghent, Belgium · 7 - Department of Electronics and Telecommunications, Politecnico di Torino, Italy · 8 - UMR7262 PALEVOPRIM, Univ. de Poitiers-CNRS, France · 9 - Department of Archaeology, Univ. of Cambridge, UK · 10 - School of Geography, Univ. of the Witwatersrand, South Africa · 11 - Department of Anthropology, UCL, UK · 12 - Department of Anatomy, Midwestern Univ., AZ, USA · 13 - LIX, Ecole Polytechnique-CNRS, Paris, France · 14 - Department of Anthropology and Human Genetics, Charles University, Czech Republic · 15 - UAR 3468 BBEES, MNHN-CNRS, France · 16 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Germany · 17 - Division of Anthropology, American Museum of Natural History, NY, USA · 18 - Department of Anatomy, Univ. of Pretoria, South Africa · 19 - Operational Direction Earth and History of Life, Institute of Natural Sciences, Brussels, Belgium · 20 - LABO, Faculty of Medicine, Univ. Libre de Bruxelles, Belgium · 21 - Department of Musculoskeletal and Ageing Science, Univ. of Liverpool, UK · 22 - UMR7268 ADES, AMU-CNRS-EFS, Marseille, France · 23 - Department of Evolutionary Biology, Univ. of Vienna, Austria · 24 - Konrad Lorenz Institute for Evolution and Cognition Research, Klosterneuburg, Austria · 25 - Polytechnic University of Turin, Italy · 26 - Mammal Collection, Natural History Museum Vienna, Austria · 27 - Institute of Evolutionary Medicine, Univ. of Zurich, Switzerland · 28 - UMR7179 MECADEV, CNRS-MNHN, Paris, France · 29 - CERMEP Imagerie du vivant, Bron, France · 30 - Centre de recherche INRIA Rennes-Bretagne Atlantique, France · 31 - Service de Chirurgie Osseuse et Traumatologique, GH Diaconesses-Croix Saint-Simon, France · 32 - TIMC, Grenoble Alpes University, France · 33 - Department of Anthropology, University of Delaware, USA · 34 - Department of Archaeology PalaeoHub, Univ. of York, UK · 35 - LBA, AMU-Gustave Eiffel University, Marseille, France · 36 - LAAS, CNRS-Univ. de Toulouse, France · 37 - Senckenberg Research Institute and Natural History Museum Frankfurt, Germany · 38 - Institute for Archaeological Research, Univ. of Cambridge, UK

Among primates, hominins represent the sole clade in which bipedalism is the main positional mode of posture and locomotion. Bipedalism is thus widely recognized as a key trait facilitating their adaptive success. Identifying and reconstructing the posture and the dynamics of bipedalism from skeletal material, however, remains an enduring challenge in paleoanthropological research, one that has significantly shaped the discourse of our field for decades.

Major palaeoanthropological discoveries and anatomo-functional progress in recent decades have added valuable information to the knowledge of the evolution of bipedal locomotion. Particularly, this research challenges the notion of a linear locomotor evolution from the earliest to the latest hominins. Instead, it is likely that different forms of bipedal locomotion were used by distinct hominins, sometimes contemporaneously [1-3]. Previous works have also underlined difficulties in studying the locomotion of fossil specimens, obstacles attributed mainly to fragmentary, scarce and heterogeneous remains as well as evolutionary mosaicism. Locomotor interpretations of fossil remains are further hampered by disputed views on the functional outcomes of characteristic postcranial hominin traits, while form-function relationships are notoriously difficult to test, especially in the absence of any comparable extant primate analogs.

Here, we introduce and present the International Research Network (IRN) “Bipedal Equilibrium” piloted by the CNRS Ecologie & Environnement. Since its inception in 2017, this network has approached the study of bipedalism from the largest perspective possible, bringing together researchers working in palaeoanthropology, primatology, functional anatomy, biomechanics, ichnology, computer science and epistemology.

The project is divided into 3 thematic axes and 3 transversal workshops covering different themes and objectives relating to bipedalism. The first axis focuses on the functional relationships between anatomical features and bipedalism and their applications to fossil taxa. It also discusses the use of locomotor grades (e.g., facultative, habitual bipedalism) and their relevance to interpreting locomotor-related features in the fossil record and in extant human and non-human primates. The second axis investigates and compares the biomechanics of bipedalism in extant human and non-human primates. It aims to elucidate the differences and commonalities of extant primate bipedal walking to identify criteria of efficiency and to what extent these

criteria can be used to infer function in fossil morphology. The third axis focuses on the impact of bipedalism on pelvic floor configuration, and its obstetrical implications (e.g. dystocic labor), and more broadly on palaeo-obstetrics, building on the success of a previous IRN showing that the evolution of difficult birth is more tightly linked to our bipedal locomotion rather than to increased brain size [4].

The first transversal workshop focuses on reconstruction, experimentation and simulation. Within this framework, IRN team members notably set up experimental equipment for encouraging arboreal bipedalism in captive chimpanzees and collecting video data at the zoological park of La Vallée des Singes (France). The second deals with databases focused on current and fossil locomotor anatomy and the biomechanics of bipedalism. The third is epistemological, exploring how we conceptualize and define the term bipedalism itself. We have developed a survey open to our broad multidisciplinary community with the goal of mapping the diverse frameworks used in the study of bipedalism. In the spirit of eliciting further interaction on the topic, all participants of the 2025 ESHE meeting are invited to take part in this survey and discuss it with members of the IRN.

The IRN Bipedal Equilibrium welcome any researcher involved in this topic in a large comparative and interdisciplinary perspective.

The International Research Network IRN-GDRI0870 Bipedal equilibrium is funded by the CNRS Ecology & Environment (France)

References: [1] Haile-Selassie, Y., Saylor, B.Z., Deino, A., Levin, N.E., Alene, M., Latimer, B.M., 2012. A new hominin foot from Ethiopia shows multiple Pliocene bipedal adaptations. *Nature*. 483, 565–569. [2] McNutt, E.J., Hatala, K.G., Miller, C., Adams, J., Casana, J., Deane, A.S., Dominy, N.J., Fabian, K., Fannin, L.D., Gaughan, S., Gill, S.V., Gurtu, J., Gustafson, E., Hill, A.C., Johnson, C., Kallindo, S., Kilham, B., Kilham, P., Kim, E., Liutkus-Pierce, C., Maley, B., Prabhat, A., Reader, J., Rubin, S., Thompson, N.E., Thornburg, R., Williams-Hatala, E.M., Zimmer, B., Musiba, C.M., DeSilva, J.M., 2021. Footprint evidence of early hominin locomotor diversity at Lactoli, Tanzania. *Nature*. 600, 468–471. [3] Stamos, P.A., Alemseged, Z., 2023. Hominin locomotion and evolution in the Late Miocene to Late Pliocene. *Journal of Human Evolution*. 178, 103332. [4] Frémondrière, P., Thollon, L., Marchal, F., Fornai, C., Webb, N.M., Haeusler, M., 2022. Dynamic finite-element simulations reveal early origin of complex human birth pattern. *Communications Biology*. 5, 1–10.

Poster Presentation Number 16, Session 1, Thursday 14:00 - 15:30

## Formation processes and chronology of the Kranskraal donga, Modder River, South Africa

Beatrice Bin<sup>1,2</sup>, Mailys Richard<sup>1</sup>, Benoit Longet<sup>1,2</sup>, Will Archer<sup>3,4,5,6</sup>, Michael B. Toffolo<sup>1,2</sup>

1 - Archéosciences Bordeaux, UMR 6034 CNRS-Bordeaux Montaigne University, France · 2 - National Research Centre on Human Evolution, Spain · 3 - Max Planck Partner Group, Department of Archaeology and Anthropology, National Museum, Bloemfontein, South Africa · 4 - Florisbad Quaternary Research Station, National Museum, Bloemfontein, South Africa · 5 - Department of Geology, University of the Free State, Bloemfontein, South Africa · 6 - Department of Anthropology, The George Washington University, Washington DC

Anatomically modern humans emerged in Africa during the Middle Pleistocene and their appearance overlaps with the onset of the archaeological period known as the Middle Stone Age (MSA). During this time, *Homo sapiens* expanded in a wide range of environments in Africa and enduringly settled in various ecosystems. Considering the size of the continent, relatively little is known about the timing and modes of *H. sapiens* dispersal within Africa. In order to better understand the spatiotemporal dimension of this process, it is useful to address the issue at subcontinental or regional scale by looking at different ecosystems in limited portions of the continent, which can offer ways of evaluating human response to environmental change during the Pleistocene. In this context, freshwater availability might have represented a key factor affecting human adaptive strategies. In the case of the South African interior, and especially the Free State Province, which features a mosaic of semi-arid grasslands and shrublands dissected by sporadic rivers, ancient water courses and wetlands may have provided early *H. sapiens* with favorable conditions and possible dispersal routes. However, the Pleistocene is currently poorly known in this region due to a lack of well-dated archaeological and sedimentary contexts at open-air sites, which are the most common occurrence in the landscape of the interior plateau [1]. Here the local geology is not favorable to cave formation, and for that reason artifacts and fossils are usually found at the surface, without the sedimentary matrix necessary for trapped-charge dating and to understand formation processes. In some cases, archaeological sites are found embedded in river terraces exposed by erosion, which offer the possibility to obtain absolute ages. Since these sites are part of open sedimentary systems and they are subject to post-depositional processes that may hamper a proper assessment of their age, it is important to study the depositional environment of trapped-charge dating samples. Consequently, a careful reconstruction of the formation processes is necessary for obtaining a correct interpretation of human occupation and accurate age determinations. At Kranskraal, an erosional gully (locally called donga) located about 25 km northeast of Bloemfontein, in the mid-upper reach of the Modder River, fossils and MSA artifacts of possible Marine Isotope Stage 5 age were found in the 1920s by E.C.N. van Hoepen [2]. Based on the micromorphological analysis of sediments, we were able to reconstruct the formation processes of luminescence dating samples collected from a geological section at the donga and to obtain age determinations for the sedimentary unit in which the artifacts are embedded. Single grain analyses were conducted on both quartz and feldspars using the thermally transferred optically stimulated luminescence (TT-OSL) and the post-infrared infrared stimulated luminescence (pIRIR290) protocols, respectively. This research contributes to the development of a chronological framework for the MSA of the Modder River basin and to a better understanding of the role of freshwater in the distribution of human groups in the interior of South Africa.

References: [1] Toffolo, M.B., 2024. Pleistocene archaeology and environments of the Free State, South Africa. *Azania: Archaeological Research in Africa*. 59, 317351. [2] van Hoepen, E.C.N., 1932. Die Mosselbaaise Kultuur. *Argeologiese Navorsing van die Nasionale Museum Bloemfontein*. 1, 27–54.

Podium Presentation, Session 7, Saturday 08:30 – 10:30

## Morpho-functional analysis of new hominin associated shoulder remains from the Shungura Formation, Lower Omo Valley (Ethiopia) provides insights on the ecology of early *Homo*

Alicia Blasi-Toccaceli<sup>1,2</sup>, Guillaume Daver<sup>1</sup>, Tiphaine Brusse<sup>1</sup>, Tea Jashashvili<sup>3,4,5</sup>, Jean-Luc Voisin<sup>6</sup>, Laurent Pallas<sup>1,7,8</sup>, Mathieu Domalain<sup>9</sup>, Jérôme Surault<sup>1</sup>, Blade Engda Redae<sup>1,10,11,12</sup>, Jean-Renaud Boissarie<sup>1,12</sup>

1 - PALEVOPRIM, CNRS, Université de Poitiers, Poitiers, France · 2 - Department of Anatomy, Midwestern University, AZ, USA · 3 - Division of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, CA, USA · 4 - Department of Radiology, Keck School of Medicine, University of Southern California, CA, USA · 5 - Department of Geology and Paleontology, Georgian National Museum, Tbilisi, Georgia · 6 - Aix Marseille Université, CNRS, EFS, ADES, Marseille, France · 7 - Kyoto University, Graduate School of Science, Laboratory of Physical Anthropology, Kyoto, Japan · 8 - HNHP, UMR 7194, MNHN/CNRS/UPVD, Paris, France · 9 - Institut PPrime UPR CNRS 3346, ENSMA, Université de Poitiers, Poitiers, France · 10 - Ethiopian Heritage Authority, Addis Ababa, Ethiopia · 11 - Institute of Human Origin, Arizona State University, AZ, USA · 12 - Centre Français des Etudes Ethiopiennes, UAR CNRS 3137, Ministère de l'Europe et des affaires étrangères, Addis Abeba, Ethiopie

The genus *Homo* is understood to have ecologically diverged from australopiths, namely *Australopithecus* and *Paranthropus*, between 2.8 Ma and 1.9 Ma [1,2]. Compared to australopiths, *Homo* is expected to show a significant reduction in arboreal locomotion, enhancements in terrestrial bipedalism, long-distance walking, endurance running, and increase of dextrous activities (*sensu* Prost, 1965) [3,4]. However, testing the extent to which these behaviors defined the ecological niche of extinct *Homo* has been considerably hindered by the limited associated remains and fragmentary fossil record, further complicated by varying preservations, ontogenetic differences, and considerable individual variations.

We present here new adult postcranial remains assigned to the individual OMO VE 3-10063 from the Shungura Formation (Lower Omo Valley, Ethiopia), dated to about 1.84 Ma. These associated remains comprise a subcomplete shoulder and forelimb, including a half lateral clavicle, a complete humerus, a partial scapula, two vertebral fragments and a rib fragment. Using qualitative comparative anatomy, linear and angular measurements, as well as 2D and 3D geometric morphometrics analyses, we compared all elements of this individual with extant hominoids (*Homo sapiens*, n>15; *Pan troglodytes*, n>15; *Pan paniscus*, n>15; *Gorilla* spp., n>15; *Pongo* spp., n>10) and Plio-Pleistocene hominins (up to n=14).

A comparative anatomical analysis reveals that OMO VE 3-10063 possess a combination of features distinguishing it from australopiths and taxonomically aligning it closer to early *Homo*. Notably, OMO VE 3-10063 exhibits a morphology of the distal humerus close to *Homo sapiens* and *Homo erectus*, a trait that has been proven reliable for taxonomic attribution in hominins. Thus, we argue here for an attribution to *Homo cf. erectus*, making its shoulder complex the oldest and best-preserved reliably assigned to the genus *Homo*. Functionally, the associated remains from Shungura display a shoulder complex that has low mechanical advantages for climbing and suspension, with, for instance, an orientation of the glenoid of the scapula intermediate between extant humans and extant apes, reduced space for the rotator cuff muscles as in extant humans, and a clavicle exhibiting a morphology similar to extant humans. That suggests that the constraints acting on the forelimb were closer to those acting on extant *H. sapiens* than those acting on extant apes. This result indicates that some members of the genus *Homo* had already restricted functions of the forelimb in arboreal locomotion as early as 1.8 Ma and are consistent with habitual terrestrial bipedalism and endurance running. Nevertheless, comparative analysis with upper limb evidence from the slightly geologically younger Dmanisi hominins (1.77 Ma) reveals that OMO VE 3-10063 exhibits more derived shoulder and forelimb than Dmanisi, that retains certain primitive traits closer to australopiths [5]. These variations highlight regional morphological and functional variation within early *Homo*, suggesting diverse adaptive strategies during the early Pleistocene. When integrating the results of this study into a broader archeological context, given the numerous pieces of evidence associating early *H. erectus* with intensification of lithic tool making and using, we hypothesize that the shoulder of *Homo* could have been selected to enhance dextrous activities (*sensu* Prost, 1965). Finally, this study confirms the morphological and behavioral differences between *Homo* and australopiths and broadly suggests that *Homo* diverged early from *Paranthropus* on ecological ground.

Funding: project LocHoSIM (AAPR 2020-2020-8624210), project COVAROS (AAPR 2024A-2024-32945810), the International Research Network "Bipedal equilibrium" (CNRS-INEE GDRI0870), the ANR HOMTECH (ANR-17-CE27-0005-02), project OGRE, Ecole doctorale Théodore Monod – Université de Poitiers.

References: [1] Hammond, A.S., Mavuso, S.S., Biernat, M., Braun, D.R., Jinnah, Z., Kuo, S., Melaku, S., Wemanya, S.N., Ndiema, E.K., Patterson, D.B., Uno, K.T., Palcu, D.V., 2021. New hominin remains and revised context from the earliest *Homo erectus* locality in East Turkana, Kenya. *Nature Communications*. 12, 1939. [2] Villmoare, B., Kimbel, W.H., Seyoum, C., Campisano, C.J., DiMaggio, E.N., Rowan, J., Braun, D.R., Arrowsmith, J.R., Reed, K.E., 2015. Early *Homo* at 2.8 Ma from Ledi-Geraru, Afar, Ethiopia. *Science*. 347, 1352-1355. [3] Bramble, D.M., Lieberman, D.E., 2004. Endurance running and the evolution of *Homo*. *Nature*. 432, 345-352. [4] Larson, S.G., 2007. Evolutionary transformation of the hominin shoulder. *Evolutionary Anthropology: Issues, News, and Reviews*. 16, 172-187. [5] Lordkipanidze, D., Jashashvili, T., Vekua, A., de León, M.S.P., Zollikofer, C.P.E., Rightmire, G.P., Pontzer, H., Ferring, R., Oms, O., Tappen, M., Bukhsianidze, M., Agusti, J., Kahlke, R., Kiladze, G., Martinez-Navarro, B., Mouskhelishvili, A., Nioradze, M., Rook, L., 2007. Postcranial evidence from early *Homo* from Dmanisi, Georgia. *Nature*. 449, 305-310.

Poster Presentation Number 17, Session 1, Thursday 14:00 - 15:30

## Evidence for climbing behaviour in fossil hominins from the trabecular bone of the distal tibia

Sofie Blik<sup>1</sup>, Jaap Saers<sup>2</sup>

1 - Department of Archaeological Sciences, Leiden University, The Netherlands · 2 - Department of Anthropology, Emory University, Atlanta, USA

The general skeletal morphology of several Plio-Pleistocene hominin taxa presents as a mosaic. Often, retained anatomical traits indicative of arboreal locomotion, associated with extant apes, are present alongside apparent adaptations for upright walking. This is the case for *Homo naledi*, *Australopithecus sediba*, and *Australopithecus africanus*. The question remains whether the ‘ape-like’ traits mean that these fossil hominins were practising a mixed locomotor repertoire, including arboreal and terrestrial locomotion, or if these traits were remnants of a previous form, no longer serving a purpose.

In this study, the trabecular structure in the distal tibia of the three hominin taxa is compared to a sample of *Homo sapiens* and extant ape tibias to see which trabecular signal the extinct hominins most closely resemble and what signals for locomotion can be discerned. The trabecular bone structure in the distal tibia can show the functional adaptation of the ankle joint and inform about the use of the ancestral traits for locomotion in the selected hominins. Trabecular bone in joints responds to the mechanical loading placed upon the joint during locomotion. The functional adaptation of the trabecular bone can thus provide information about the stress placed on a joint during the life of an individual [1].

Using ORS Dragonfly [2], high-resolution CT data was segmented by applying Deep Learning methods in the program to separate the bone from the matrix. Ten volumes of interest (VOI) in the distal epiphysis of the tibia were extracted for every specimen. For every VOI, the relative trabecular bone density (rBV/TV) and the degree of anisotropy (DA) in the distal epiphysis of the tibias were calculated in ImageJ (BoneJ plug-in) to analyse the loading pattern throughout the articular region of the distal tibia.

The results show that the trabecular loading (BV/TV) and orientation (DA) in the distal tibias of the studied fossil hominins group closely with extant apes, despite the external morphology of the hominins aligning more with modern humans. Furthermore, areas of high rBV/TV in the fossil hominins on the anterior border of the distal articular surface of the tibia may indicate regular hyperdorsiflexion of the foot at the ankle joint, where the talus turns onto the anterior distal tibia and transmits force, resulting in a more robust area of bone. Both results indicate that these hominins were frequent climbers, or alternatively squatting, despite having ‘human-like’ ankle morphology. These results emphasize the great importance of climbing in the locomotor repertoires of these hominin taxa, compared to *Homo sapiens*, from australopithecines to *Homo naledi*.

References: [1] Kivell, T.L., 2016. A review of trabecular bone functional adaptation: what have we learned from trabecular analyses in extant hominoids and what can we apply to fossils? *Journal of Anatomy*. 228, 569–594. [2] Comet Technologies Canada Inc., Montreal, Canada; software available at <https://www.theobjects.com/dragonfly>

Poster Presentation Number 18, Session 1, Thursday 14:00 - 15:30

## The Trans-Evol Project: mapping evolution in the south-west of the Turkana Basin

Marjolein D. Bosch<sup>1,2,3</sup>, Fredrick Kyalo Manthi<sup>4</sup>, Sol Sánchez-Dehesa Galán<sup>3,5,6</sup>, Cécile Chapon-Sao<sup>7</sup>, Hema Achyuthan<sup>8</sup>, Mikel Arlegi<sup>7,9</sup>, Jean-Jacques Bahain<sup>7</sup>, Justus Erus Edung<sup>4</sup>, Robert A. Foley<sup>3,10</sup>, Hugo Hautavoine<sup>7</sup>, Alexis Nutz<sup>11</sup>, Jean-Luc Schwenninger<sup>12</sup>, Emmanuelle Stoetzel<sup>7</sup>, Ann Van Baelen<sup>13</sup>, Juan Marín<sup>14</sup>, Céline Vidal<sup>15</sup>, Marta Mirazón Lahr<sup>3,10</sup>, Aurélien Mounier<sup>3,7,16</sup>

1. Department of Prehistoric and Historical Archaeology, University of Vienna, Vienna, Austria · 2. Austrian Archaeological Institute – Prehistory, Austrian Academy of Sciences, Vienna, Austria · 3. Turkana Basin Institute, Nairobi, Kenya · 4. National Museums of Kenya, Nairobi, Kenya · 5. Msca-cofund usal4excellence, Prehistoria, Historia Antigua y Arqueología Department, Universidad de Salamanca, Spain · 6. Temps-UMR8068 CNRS/UP1/UPN, Nanterre, France · 7. Histoire Naturelle des Humanités Préhistoriques (HNHP, UMR 7194), PaleoFED, MNHN/CNRS/UPVD, Musée de l'Homme, Paris, France · 8. Department of Geology, Anna University, Chennai, India · 9. McDonald Institute for Archaeological Research, University of Cambridge, UK · 10. Department of Archaeology, University of Cambridge, UK · 11. CEREGE, Aix-Marseille Université, CNRS, IRD, Collège de France, INRAE, Aix-en-Provence, France · 12. School of Archaeology, University of Oxford, UK · 13. Academic and Historical Heritage Office, KU Leuven, Belgium · 14. Departamento de Prehistoria y Arqueología, UNED, Madrid, Spain · 15. Fitzwilliam College, Department of Geography, University of Cambridge, UK · 16. CNRS, UAR 3129 – UMIFRE 11 3 Maison Française d'Oxford, Oxford, UK

The appearance of our species 235 thousand years ago (ka) in Africa is one of the many stages in a long and complex evolutionary process that gave rise to numerous hominin species. The Turkana Basin, in the East African Rift, contains a wealth of archaeological and paleontological evidence illustrating these evolutionary stages. This evidence is unevenly distributed across the region, with the archaeological potential of many areas still largely overlooked. In this context, the Trans-Evol project leads archaeological fieldwork in the southwestern Turkana Basin, northern Kenya, focusing on a key period for human evolution: the transition between the Early and the Middle Pleistocene (i.e., EMPT, 1250 to 750 ka). This period is characterized by drastic climatic and environmental upheavals that affected all ecosystems, including past human populations as illustrated by behavioural and biological innovations appearing at the time. Mode 2 technology and its typical Acheulean handaxes becomes more complex, also expanding its distribution to new regions of the world. Whether these technical changes reflect more flexible technological responses to raw material availability and mobility or biological diversification of hominin populations remains difficult to assess. Only three well-preserved human fossils from the African EMPT have been recovered so far, and African fauna-bearing Acheulean sites dating to the EMPT for which anthropogenic modifications were reported are scarce. Hominin populations of the time are therefore poorly understood. The Trans-Evol project aims at contributing to furthering our knowledge of EMPT hominin populations through the identification and excavation of new archaeological sites in the fossil-rich Turkana Basin.

For the past four years, the project has been surveying an area of approximately 150 km<sup>2</sup> of the southwest of the Turkana Basin where 12 localities of interest have been identified. Among those, Kanyimangin and Kamilikol are particular important. Kanyimangin has yielded a large faunal sample and over 400 lithic artefacts which are consistent with an EMPT occupation of the site. The dating of this locality to 0.9-1.18 Ma via biostratigraphy and magnetostratigraphy confirms that Kanyimangin is one of the few Early Pleistocene sites of East Africa that encompasses the EMPT. Kamilikol is located 10 km to the southwest and preliminary geological assessments suggest a comparable age to Kanyimangin. The site has yielded a large sample of lithic artefacts, recovered both from surveys and excavation, presenting clear Acheulean characteristics. No less than 70 of those artefacts are handaxes, making Kamilikol a unique archaeological site with no counterparts in West Turkana. These two new sites in Southwest Turkana – Kanyimangin and Kamilikol, represent major new palaeontological and archaeological additions to the hominin record in East Africa during the key period of the EMPT.

Funding: International Research Project (LIA1262, CNRS-INEE), the French Foreign Office (MEAE) and the Fyssen Foundation. We thank the In-Africa and Ng'ipalajem Projects, the National Museums of Kenya, the Turkana Basin Institute, the French Embassy in Nairobi and the French Institute for Research in Africa of Nairobi for logistic support.

Podium Presentation, Session 1, Thursday 09:20 – 11:00

## From rock art to cave walls: exploring new sources of ancient human DNA

Alba Bossoms Mesa<sup>1</sup>, Elena Essel<sup>1</sup>, Louisa Jáuregui<sup>1</sup>, Aurore Galtier<sup>1</sup>, Elena I. Zavala<sup>1,2,3</sup>, Kevin Nota<sup>1</sup>, Merlin Szymanski<sup>1</sup>, Julia Zorn<sup>1</sup>, Hugo Gomes<sup>4,5</sup>, George H. Nash<sup>5,6</sup>, Pierluigi Rosina<sup>4,5</sup>, Virginia Lattao<sup>5,7,8</sup>, Luiz Oosterbeek<sup>4,5</sup>, Carlos Carpetudo<sup>9</sup>, Nelson A. Almeida<sup>10</sup>, Carmen de las Heras<sup>11</sup>, Pilar Fatás<sup>11</sup>, Alfredo Prada<sup>11</sup>, Lucía M. Díaz-González<sup>11</sup>, M. Elena Sánchez-Moral<sup>11</sup>, Alberto Martínez Villa<sup>12</sup>, Mario Menéndez Fernández<sup>13</sup>, José Julio García Arranz<sup>14</sup>, Pedro Cantalejo<sup>15</sup>, Luis-Efrén Fernández<sup>15</sup>, José Ramos Muñoz<sup>15</sup>, Diego S. Fernández Sánchez<sup>16</sup>, Hugo A. Mira<sup>17</sup>, Emilio Muñoz Fernández<sup>18</sup>, Ramón Montes-Barquín<sup>19</sup>, Roberto Ontañón<sup>20,21</sup>, Janet Kelso<sup>1</sup>, Benjamin Vernot<sup>1</sup>, Mateja Hajdinjak<sup>1</sup>, Shao Qinfeng<sup>22</sup>, Sara Garcês<sup>4,5</sup>, Hipólito Collado Giraldo<sup>7,14,23</sup>, Matthias Meyer<sup>1</sup>

1 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 2 - Department of Forensic Medicine, University of Copenhagen, Copenhagen, Denmark · 3 - The Globe Institute, University of Copenhagen, Copenhagen, Denmark · 4 - Polytechnic Institute of Tomar, Tomar, Portugal · 5 - Earth and Memory Institute, Geosciences Centre, Portugal · 6 - Department of Archaeology, Classics & Egyptology, University of Liverpool, UK · 7 - University of Coimbra, Coimbra, Portugal · 8 - Museum of Prehistoric and Sacred Art of the Tagus Valley, Municipality of Mação, Portugal · 9 - Municipality of Montemor o Novo, Portugal · 10 - Culture Unit, Alentejo Regional Coordination and Development Commission. Crato Extention, Portugal · 11 - Museo Nacional y Centro de Investigación de Altamira, Santillana del Mar, Spain · 12 - Centro de Investigación Fauna Glaciar, Onís, Spain · 13 - Universidad Nacional de Educación a Distancia, Madrid, Spain · 14 - University of Extremadura, Cáceres, Spain · 15 - University of Cádiz, Cádiz, Spain · 16 - Complutense University of Madrid, Madrid, Spain · 17 - Instituto de Estudios Campogibraltareños, Algeciras, Spain · 18 - Colectivo para la Ampliación de Estudios de Arqueología Prehistórica, Santander, Spain · 19 - Itinerario Cultural Europeo PRAT-CARP, Spain · 20 - Museo de Prehistoria y Arqueología de Cantabria, Santander, Spain · 21 - Cuevas Prehistóricas de Cantabria. Gobierno de Cantabria, Spain · 22- Nanjing Normal University, China · 23- Junta de Extremadura, Mérida, Spain

While palaeogenetics has significantly advanced our understanding of human prehistory by linking archaeological assemblages to ancient populations through the analysis of ancient skeletal remains, sediments, and artifacts [1-3], some aspects of the cultural record remain inaccessible to genetic investigation. A notable example is rock art: although it represents an important expression of human culture, it usually lacks a direct association with excavated cave floors, precluding genetic inferences about its creators. It is plausible that the application of pigment to cave walls—whether mouth-blown or hand-applied—may have left traces of the artists' DNA in the artworks. Thus, within the framework of the First Art project [4], a multidisciplinary study focused primarily on dating rock art and chemical analyses of pigment, we set out to assess the potential for recovering ancient DNA (aDNA) from early Palaeolithic rock art in 11 caves across Spain and Portugal.

In total, we obtained pigment samples from 33 panels, mostly consisting of non-figurative motifs applied preferentially with red ochre (iron-oxide based pigment), including motifs such as dots, lines and claviforms, along with recognisable images such as hand-stencils. The sampling strategy was adapted to the specific conditions of each cave: in most cases, small pigment-containing samples of the cave wall were removed using a scalpel; in others, such as a figurative panel from Altamira cave (Cantabria, Spain), naturally eroding pigments were passively collected using gauze or gathered from drip water. We additionally collected control samples from unpigmented cave walls to account for background DNA loads and attempted DNA recovery from an airbrush excavated in Altamira cave, a tool probably once used to spray pigment onto cave walls. DNA was extracted using a method optimized for aDNA recovery from bones, sediments and minerals, converted into single-stranded DNA libraries and enriched for mitochondrial DNA (mtDNA) using two rounds of hybridization capture. Using a custom computational pipeline (quicksand v2.3, <https://github.com/mpieva/quicksand>) we assigned DNA sequences to mammalian families and evaluated for the presence of deamination-induced aDNA damage. In cases where ancient human mtDNA was detected, libraries were also enriched for 1.35 million ancestry-informative positions in the human nuclear genome [5].

Based on preliminary results, ancient human DNA was identified in one pigmented cave wall sample and two unpigmented control samples from Escoural cave (Alentejo, Portugal), as well as in two control samples from Covarón (Asturias, Spain). While too little ancient human DNA was extracted from the Escoural cave samples for further analysis, substantial amounts of ancient nuclear DNA were recovered from the unpigmented Covarón cave samples, providing evidence for an association with Mesolithic western hunter-gatherers. All samples yielded little or no amounts of faunal DNA, suggesting that human contact was indeed the primary source of DNA deposition on the cave walls. While the retrieval of DNA from unpigmented samples complicates attempts to directly associate rock art with the DNA of its makers, the finding that cave walls can preserve ancient human DNA opens up a new resource for genetic studies of past populations.

Data was produced by the Ancient DNA Core Unit of the Max Planck Institute for Evolutionary Anthropology which is funded by the Max Planck Society. Sara Garcês, Hugo Gomes, Virginia Lattao, Pierluigi Rosina, Hipólito Collado, Luiz Oosterbeek and George Nash are supported by Portuguese funds from Fundação para a Ciência e a Tecnologia, I.P. (Portugal) in the frame of UIDB/00073/2025 and the UIDP/00073/2025 projects of the I & D unit of Geosciences Center (University of Coimbra, Portugal). The First Art project was supported by INTERREG POCTEP funded by the European Regional Development Fund (ERDF) (Grant N°: 0497\_FIRST\_ART\_4\_E). We also want to thank Pablo Solares Villar and David López Herráez, who provided support throughout caving expeditions.

References: [1] Mylopotamitaki, D., Weiss, M., Fewlass, H., Zavala, E.I., Rougier, H., Sümer, A.P., Hajdinjak, M., Smith, G.M., Ruebens, K., Sinet-Mathiot, V., Pederzani, S., Essel, E., Harking, F.S., Xia, H., Hansen, J., Kirchner, A., Lauer, T., Stahlschmidt, M., Hein, M., Talamo, S., Wacker, L., Meller, H., Dietl, H., Orschiedt, J., Olsen, J.V., Zeberg, H., Prüfer, K., Krause, J., Meyer, M., Welker, F., McPherron, S.P., Schüller, T., Hublin, J.-J., 2024. *Homo sapiens* reached the higher latitudes of Europe by 45,000 years ago. *Nature*. 626, 341–346. [2] Slon, V., Hopfe, C., Weiß, C.L., Mafessoni, F., de la Rasilla, M., Lalueza-Fox, C., Rosas, A., Soressi, M., Knul, M.V., Miller, R., Stewart, J.R., Derevianko, A.P., Jacobs, Z., Li, B., Roberts, R.G., Shunkov, M.V., de Lumley, H., Perrenoud, C., Gušić, I., Kućan, Ž., Rudan, P., Aximu-Petri, A., Essel, E., Nagel, S., Nickel, B., Schmidt, A., Prüfer, K., Kelso, J., Burbano, H.A., Pääbo, S., Meyer, M., 2017. Neandertal and Denisovan DNA from Pleistocene sediments. *Science*. 356, 605–608. [3] Essel, E., Zavala, E. I., Schulz-Kornas, E., Kozlikin, M. B., Fewlass, H., Vernot, B., Shunkov, M. V., Derevianko, A. P., Douka, K., Barnes, I., Soulier, M.-C., Schmidt, A., Szymanski, M., Tsanova, T., Sirakov, N., Endarova, E., McPherron, S. P., Hublin, J.-J., Kelso, J., Pääbo, S., Hajdinjak, M., Soressi, M., Meyer, M., 2023. Ancient human DNA recovered from a Palaeolithic pendant. *Nature*. 618, 328–332. [4] Collado, H., Garcés, S., Almeida, N.A.C., Carpetudo, C., Gomes, H., Lattao, V., Nash, G., Rosina, P., Vaccaro, C., Shao, Q., Meyer, M., Bossoms Mesa, A., García, J. J., Fernandez, D.S., Perales, H.M., 2021. El proyecto FIRST ART. Evolución y desarrollo de una metodología integral para el estudio del Arte Rupestre. II Cóa Symposium – A gestão e conservação de sítios com Arte Rupestre, Museu do Cóa. [5] Rohland, N., Mallick, S., Mah, M., Maier, R., Patterson, N., Reich, D., 2022. Three assays for in-solution enrichment of ancient human DNA at more than a million SNPs. *Genome Research*, 32, 2068–2078.

Poster Presentation Number 19, Session 1, Thursday 14:00 - 15:30

## Tracing tropical adaptation: new isotopic perspectives on human diet in Late Quaternary Sri Lanka

Nicolas Bourgon<sup>1,2</sup>, Marcus Oelze<sup>2</sup>, Noel Amano<sup>1</sup>, Oshan Wedage<sup>3</sup>, Patrick Roberts<sup>1</sup>

1 - Department of Coevolution of Land Use and Urbanisation, Max Planck Institute of Geoanthropology, Jena, Germany · 2 - Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany · 3 - Department of History and Archaeology, University of Sri Jayawardenepura, Gangodawila, Nugegoda, Sri Lanka

The longstanding assumption that tropical rainforests served as ecological barriers to Pleistocene human dispersals [1] has been increasingly challenged in recent years [2,3]. A growing body of archaeological evidence now demonstrates that *Homo sapiens* not only entered these environments but also repeatedly adapted to their unique ecological challenges, developing simultaneously diverse and specialized approaches to subsistence. Sri Lanka offers one of the richest archaeological records for assessing long-term human–tropical forest interaction, particularly through renewed multidisciplinary excavations at four major cave sites: Balangoda Kuragala, Batadomba-lena, Fa-Hien Lena, and Kitulgala Beli-lena [3–5].

Here, we present a systematic comparison of multi-isotopic data ( $\delta^{66}\text{Zn}$ ,  $\delta^{13}\text{C}$ , and  $\delta^{18}\text{O}$ ) derived from the tooth enamel of both human individuals and associated large mammal taxa recovered from these sites. We report new  $\delta^{66}\text{Zn}$  data for 64 mammalian specimens and 28 human individuals, with  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values from the same aliquots already available. The faunal isotope record provides crucial dietary baselines for interpreting human isotope values within this ecological framework.

The human specimens span a discontinuous period from the end of the Last Glacial Maximum (~19 ka) through the Holocene. This temporal range enables us to assess whether subsistence strategies shifted in tandem with broader climatic and cultural transitions. This study represents the first large-scale application of zinc stable isotope analysis to tropical forager populations. By integrating  $\delta^{66}\text{Zn}$  data with more established  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  proxies, we aim to refine our understanding of human dietary ecology in rainforest environments. Our work also addresses the broader question of whether tropical rainforests constrained or supported human adaptive flexibility, and to what extent early foragers may have relied on plant resources in a setting where direct archaeological evidence for subsistence is often limited.

Our results indicate that mammalian  $\delta^{66}\text{Zn}$  values reflect a clear dietary gradient consistent with trophic level, offering a valuable reference for evaluating human plant–animal dietary contributions. Importantly, initial results from the human individuals suggest temporal differences in  $\delta^{66}\text{Zn}$  values, with individuals from Late Pleistocene contexts generally exhibiting lower values, indicative of greater animal protein consumption, compared to their later Holocene counterparts. This suggests a shift toward a higher reliance on plant-based resources over time, possibly reflecting changing subsistence strategies even before the introduction of agriculture.

The authors thank the Max Planck Society for financial support, and the Deutsche Forschungsgemeinschaft for funding received by N. Bourgon (project 517968067).

References: [1] Wurster, C. M. & Bird, M. I. Barriers and bridges: Early human dispersals in equatorial SE Asia. *Geological Society of London Special Publications*. 411, 235–250. [2] Summerhayes, G.R., Leavesley, M., Fairbairn, A., Mandui, H., Field, J., Ford, A., Fullagar, R., 2010. Human adaptation and plant use in highland New Guinea 49,000 to 44,000 years ago. *Science* 330, 78–81. [3] Roberts, P., Perera, N., Wedage, O., Deraniyagala, S., Perera, J., Eregama, S., Gledhill, A., Petraglia, M.D., Lee-Thorp, J.A., 2015. Direct evidence for human reliance on rainforest resources in late Pleistocene Sri Lanka. *Science*. 347, 1246–1249. [4] Perera, N., Kourampas, N., Simpson, I.A., Deraniyagala, S.U., Bulbeck, D., Kamminga, J., Perera, J., Fuller, D.Q., Szabó, K., Oliveira, N.V., 2011. People of the ancient rainforest: Late Pleistocene foragers at the Batadomba-lena rockshelter, Sri Lanka. *Journal of Human Evolution*. 61, 254–269. [5] Amano, N., Wedage, O., Ilgner, J., Boivin, N., Petraglia, M., Roberts, P., 2023. Of forests and grasslands: human, primate, and ungulate palaeoecology in Late Pleistocene–Holocene Sri Lanka. *Frontiers in Earth Science*. 11.

Podium Presentation, Session 4, Friday 08:30 – 10:30

## **The Middle and Upper Palaeolithic archaeological and palaeoenvironmental records from the Faya palaeolandscape and their contributions to the deciphering of Southeast Arabia's Pleistocene history**

**Knut Bretzke<sup>1,2</sup>, Sabah Jasim<sup>3</sup>, Eisa Yousif<sup>3</sup>, Seolmin Kim<sup>4,5</sup>, Adrian G. Parker<sup>6,7</sup>**

1 - University of Tübingen, Germany · 2 - University of Jena, Germany · 3 - Sharjah Archaeology Authority, UAE · 4 - Université Paris 1 Panthéon-Sorbonne, France · 5 - UMR 8068, Technologie et Ethnologie des Mondes Préhistorique, France · 6 - Oxford Brookes University, UK · 7 - University of Wollongong, Australia

The number of stratified and dated Paleolithic sites in Arabia has significantly increased recently, transforming the region from a perceived periphery to a key area for studying human evolution. While some periods such as the Last Interglacial (ca. 130,000-115,000 years ago) are relatively well known, others such as the Last Glacial Period (ca. 115,000-12,000 years ago) are only very sparsely represented in the archaeological records of Arabia. In this paper we will present results from 20 years of interdisciplinary research on the Palaeolithic period within the Faya Palaeolandscape in the central region of the Emirate of Sharjah (UAE) and aim at contributing to the deciphering of Southeast Arabia's Pleistocene history. We focus here on the Late and terminal Pleistocene (ca. 80,000-16,000 years ago), a period with exceptionally few archaeological records in Arabia. We provide data from two archaeological key sequences, namely Jebel Faya (FAY-NE1) and Buhais Rockshelter in addition to one palaeoenvironmental section (P6) that provide rare insight into human habitation of Southeast Arabia and adaptation to shifting environmental conditions during the Last Glacial Period. We will present new results including evidence for a Middle Palaeolithic blade technology occurring in the youngest Pleistocene layer at Jebel Faya dating to 80,000 years ago, which demonstrates a local independent developmental trajectory. Further, we will provide evidence for a late Middle Palaeolithic occupation phase about 60,000 years ago from Jebel Buhais Rockshelter, which indicates the presence of lithic traditions in Southeast Arabia that can be linked to synchronous record from site Shi'bat Dihya-1 in Yemen [1]. And finally, we will present evidence for two occupation phases at Jebel Buhais Rockshelter, which are associated with typical Upper Palaeolithic technological traditions dating to 35,000 and 16,000 years ago. Our results shed new light on the Pleistocene colonization history of southeastern Arabia and provide important new data for deciphering the role of Arabia in the process of human evolution.

We are grateful to HH Sheikh Dr. Sultan bin Muhammad Al Qasimi and the Sharjah Archaeology Authority for permission and continued support of this project. This project received funding from the Deutsche Forschungsgemeinschaft through grants to KB (BR 5562/2-1, BR 5562/6-1). SK would like to thank the French Government for receiving funding through the France Excellence program implemented by the Embassy of France in Korea. We would like to extend our sincere gratitude to Margarethe and Hans-Peter Uerpmann as well as the Buhais Rockshelter excavation teams, especially Alexander Janas.

References: [1] Delagnes, A., Tribolo, C., Bertran, P., Brenet, M., Crassard, R., Jaubert, J., Khalidi, L., Mercier, N., Nomade, S., Peigné, S., Sitzia, L., Tournepiche, J.-F., Al-Halibi, M., Al-Mosabi, A., Macchiarelli, R., 2012. Inland human settlement in southern Arabia 55,000 years ago. New evidence from the Wadi Surdud Middle Palaeolithic site complex, western Yemen. *Journal of Human Evolution*. 63, 452–474.

Poster Presentation Number 20, Session 1, Thursday 14:00 - 15:30

## A new radiocarbon biochronology for Reindeer Cave: implications for Late Pleistocene ecosystem-glacier dynamics at the extreme edge of north-west Europe during the Last Glaciation

Kate Britton<sup>1</sup>, Andrew Kitchener<sup>2</sup>, Tim Lawson<sup>1</sup>, Alicia Sanz-Royo<sup>1</sup>, Sarah Barakat<sup>1</sup>, Will Mills<sup>1</sup>, Leia Tilley<sup>1</sup>, Gordon Noble<sup>1</sup>, Elodie-Laure Jimenez<sup>1</sup>, Helen Fewlass<sup>3</sup>, Bartosz Kurjanski<sup>1</sup>, Matteo Spagnolo<sup>1</sup>, Brice Rea<sup>1</sup>

1 - University of Aberdeen · 2 - National Museums Scotland · 3 - University of Bristol

Over the past two decades our understanding of the chronology and dynamics of the last British-Irish Ice Sheet has significantly improved, constraining the timing of glacial advance, maximum extent, and retreat [1]. However, prior to 31 ka BP, geochronological evidence for ice margin positions remains patchy and have large uncertainties. Similarly, there are difficulties in reconstructing the regional glacial dynamics and ice persistence around and after 15ka BP. The dating of palaeontological (faunal) remains in areas that were fully glaciated during the Last Glacial Maximum (LGM) offers a potential avenue of evidence for local pre- and post-glacial conditions, and thus for refining (and validating) ice-sheet models. Such data also offer key information about the biological implications of glacial dynamics, including ecosystem productivity and niche availability, which in turn can inform our understanding of potential contemporary hominin population dispersal dynamics.

The caves of the Allt nan Uamh valley, Assynt, north-west Scotland [58.06694°, -4.97139°], lie at what was the extreme north-west edge of the continental European landmass during the Last Glaciation (Marine Isotope Stage 4 to 2). Excavations in the 1880s and 1920s, in particular in Reindeer Cave, produced a rich assemblage of (probable) Late Pleistocene faunal bone including reindeer, bear, wolf, lynx and wildcat. Radiocarbon dating of these remains has the potential to clarify the timing and nature of glacial advance and retreat in the region, as well as to inform site formation processes and the nature of animal (and even hominin) activities at the site. However, only a limited number of specimens have previously been dated, with some results contradicting conventional wisdom regarding regional ice-sheet dynamics –suggesting faunal presence during a period when the ice-sheet is generally accepted to have completely covered the land, extending out to the continental shelf [2,3].

Here we present new radiocarbon dates for fauna from Reindeer Cave with the goal of 1) linking direct faunal evidence with the latest models of the Last Devensian ice-sheet dynamics in the region, and 2) establishing a new biochronology for Reindeer Cave, facilitating future investigations of faunal remains at this important site. Targeting bear (*Ursus* sp.) and reindeer (*Rangifer tarandus*), collagen was extracted using an acid-base-acid pretreatment protocol [4] and dates were generated at the UK's Oxford Radiocarbon Accelerator Unit (ORAU) facility. Dates range from >47.3 ka BP (uncal.) at the base of the sequence, to the early Late Glacial (14.8 ka to 14.1 ka cal BP, 2σ; IntCal20). These new radiocarbon dates appear in stratigraphic order related to historically-recorded levels, with deposition beginning prior to ~45 ka cal BP, followed by at least two further phases of deposition, including a final depositional event pre-LGM at ~34 ka cal BP. Bone dated to ~14.5 cal ka BP from the outer chamber suggest deposition (and activity by denning species, such as bears) recommenced shortly after glacial retreat following a ~18 ka hiatus. These new dates not only resolve the earlier chronological contradictions but now help to further refine the timing of the growth and retreat of the last British-Irish Ice Sheet in the region. The dates establish a new chronological framework required for continuing studies at the site, including site formation processes; palaeontological and taphonomic analysis; and isotopic and genetic analysis of the faunal remains. Together, the new dates and ongoing research will yield key insights into the relationship between glacial dynamics, environmental and ecological change, and the potential for hominin presence throughout the Late Pleistocene in the region.

This research was funded by UK Research and Innovation (UKRI), including a NERC Discovery Science Internal Funding award [RG16808-11], and an ERC-selected/EPSC-funded grant [EP/Y023641/1]. Thanks to Orsolya Czére (Aberdeen) for technical assistance.

References: [1] Clark, C.D., Ely, J.C., Hindmarsh, R.C.A., Bradley, S., Ignézi, A., Fabel, D., Ó Cofaigh, C., Chiverrell, R.C., Scourse, J., Benetti, S., Bradwell, T., Evans, D.J.A., Roberts, D.H., Burke, M., Callard, S.L., Medialdea, A., Saher, M., Small, D., Smedley, R.K., Gasson, E., Gregoire, L., Gandy, N., Hughes, A.L.C., Ballantyne, C., Bateman, M.D., Bigg, G.R., Doole, J., Dove, D., Duller, G.A.T., Jenkins, G.T.H., Livingstone, S.L., McCarron, S., Moreton, S., Pollard, D., Praeg, D., Sejrup, H.P., Van Landeghem, K.J.J., Wilson, P., 2022. Growth and retreat of the last British-Irish Ice Sheet, 31 000 to 15 000 years ago: the BRITICE-CHRONO reconstruction. *Boreas*, 51, 699–758. [2] Lawson, T., 1984. Reindeer in the Scottish Quaternary. *Quaternary Newsletter*, 42, 1-7. [3] Murray, N., Bonsall, C., Sutherland, D., Lawson, T., Kitchener, A., 1993. Further radiocarbon determinations on reindeer remains of Middle and Late Devensian age from the Creag nan Uamh caves, Assynt, NW Scotland. *Quaternary Newsletter*, 70, 1-10. [4] Brock, F., Higham, T., Ditchfield, P., Ramsey, C.B., 2010. Current Pretreatment Methods for AMS Radiocarbon Dating at the Oxford Radiocarbon Accelerator Unit (Orau). *Radiocarbon*, 52, 103–112.

Poster Presentation Number 21, Session 1, Thursday 14:00 - 15:30

## The patterning of the effects of hybridisation across the skeleton

Laura T. Buck<sup>1,2</sup>, Rebecca Rogers Ackermann<sup>3,4</sup>, Leslea J. Hlusko<sup>5</sup>, Sree Kanthaswamy<sup>6</sup>, David C. Katz<sup>7</sup>, Timothy D. Weaver<sup>2</sup>

1 - Research Centre for Evolutionary Anthropology and Palaeoecology, Liverpool John Moores University, UK · 2 - Department of Anthropology, University of California Davis, USA · 3 - Department of Archaeology, University of Cape Town, South Africa · 4 - Human Evolution Research Institute, University of Cape Town, South Africa · 5 - Centro Nacional de Investigación Sobre la Evolución Humana (CENIEH), Burgos, Spain · 6 - School of Mathematics and Natural History, Arizona University, USA · 7 - Cell Biology and Anatomy, University of Calgary Cumming School of Medicine, Canada

Biomolecular evidence shows a complex history of interbreeding between taxa in Middle-Late Pleistocene *Homo* [1]. The phenotypic result of this is still largely unclear, leaving an important gap in our understanding of human evolution given that selection acts on the phenotype, not to mention the infeasibility of aDNA retrieval from most fossils. In the context of a sparse, valuable hominin fossil record, non-human primate models can facilitate our understanding of the phenotypic consequences of hybridisation [2]. Most discussions of hominin hybrid morphology to date have concerned the skull, but non-human primate studies have shown that postcranial size is an important indicator of hybrid identity [2,3], and we have previously suggested that cephalopelvic fit would be a key determiner of viability in hybrid offspring [4]. It is currently unknown whether skeletal regions are affected differently by hybridisation, and this information could be vital in correctly interpreting the ancestry of fragmentary fossils.

Here we describe the cranial morphology resulting from hybridisation in a sample of Chinese x Indian rhesus macaques (*Macaca mulatta*) for which we have previously characterised the influence of admixture on pelvic shape and postcranial size [3,4]. This enables us, for the first time, to compare the regional signal of hybridisation throughout the skeleton in the same individuals. Chinese and Indian rhesus macaques are suitable proxies for investigating hominin hybridisation as they have comparable divergence time (in generations) to humans/Neanderthals. Our sample is multigenerational, with percentages of Chinese introgression into the Indian colony ranging from 100% (full-bred animals) to <10% [4]. We use 3D landmark GMM on CT-derived virtual cranial surfaces (n=148) to analyse the effect of admixture on cranial shape.

Preliminary results on a cranial subsample demonstrate a similar signal to that reported for the pelvis [4]: a subtle, linear relationship between the amount of Chinese ancestry and cranial shape, with no transgressive individuals. This is in contrast to the postcranial size results [3], which not only showed a tendency towards unexpectedly small size in hybrids but also a disproportionate effect on the limbs. If borne out by analysis of the full sample, these results may show a pattern of differential canalisation within the skeleton, which affects its response to hybridisation. It has been argued that the cranium and pelvis are constrained due to complex, competing selective pressures, whereas the limbs are more free to vary without substantially maladaptive consequences to the individual [5].

Our results diverge from previous studies on hybrids between other non-human primate taxa, which have found non-linear relationships between morphology and admixture, especially greater than expected size, and atypical dental and cranial non-metric traits (e.g., [2]). These differences may be due to the relative degree of genetic/phenotypic distance between parental taxa and/or the number of generations since admixture event [3,4]. Understanding the way hybridisation affects different parts of the non-human skeleton, and is affected by the hybridising taxa, will ultimately allow us to construct informed, robust models of our expectations for hominin hybridisation and to better interpret the existing fossil record.

Funding was provided by NSF (grants #1623366 and #1720128) and The Leakey Foundation. LJH is supported by the European Research Council within the European Union's Horizon Europe (ERC-2021-ADG, Tied2Teeth, project number 101054659). RRA is supported by the National Research Foundation of South Africa (Grant No. 136512). SK is supported by NIH (grants U42OD010990-24A1 and 5P51OD011107). We thank the CNPRC for data collection and acknowledge the NIH funding to the center (P51 OD011107). We thank Sara Jhanjar and Amber Parks for their help with CT scan segmentation.

References: [1] Gokcumen, O., 2019. Archaic hominin introgression into modern human genomes. *American Journal of Physical Anthropology*. 171, 60–73. [2] Ackermann, R.R., Rogers, J., Cheverud, J.M., 2006. Identifying the morphological signatures of hybridization in primate and human evolution. *Journal of Human Evolution*. 51, 632–645. [3] Buck, L.T., Katz, D.C., Ackermann, R.R., Hlusko, L.J., Kanthaswamy, S., Weaver, T.D., 2025. A Macaque model for the effects of hybridization on body Size. *American Journal of Biological Anthropology*. 186. [4] Buck, L.T., Katz, D.C., Ackermann, R.R., Hlusko, L.J., Kanthaswamy, S., Weaver, T.D., 2021. Effects of hybridization on pelvic morphology: A macaque model. *Journal of Human Evolution*. 159, 103049. [5] Buck, L.T., Stock, J.T., Foley, R.A., 2010. Levels of intraspecific variation Within the Catarrhine skeleton. *International Journal of Primatology*. 31, 779–795.

Poster Presentation Number 22, Session 1, Thursday 14:00 - 15:30

## Morphological and ontogenetic analysis in hominid cranial fragments from the “Ruidera” paleoanthropological site

Candelas Buenestado Ruiz<sup>1</sup>, Carlos A., Palancar<sup>2</sup>, Sara Díaz-Pérez<sup>3</sup>, Manuel D. D'Angelo del Campo<sup>4,5</sup>, Óscar Cambra Moo<sup>4</sup>, Antonio García Tabernero<sup>6</sup>, Daniel García-Martínez<sup>1,7</sup>

1 - Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 2 - Grupo de Paleoantropología, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (MNCN - CSIC) · 3 - Institute of Archaeology, University of Wrocław, Wrocław, Poland · 4 - Laboratorio de Poblaciones del Pasado, Departamento de Biología, Facultad de Ciencias, Universidad Autónoma de Madrid, Madrid, Spain · 5 - Social Science Department, Universidad Nacional del Centro de la Provincia de Buenos Aires, Quenquén, Argentina · 6 - Physical Anthropology Area, Biology and Environmental Department, Universidad de León, León, Spain · 7 - Centre for Functional Ecology, Laboratory of Forensic Anthropology, Department of Life Sciences, University of Coimbra, Coimbra, Portugal

The paleoanthropological site of Ruidera provides valuable insights into the human fossil record of the Iberian Peninsula, despite the uncertainty surrounding the taxonomic classification of its specimens. The dating of the site, established through ESR-Uranium and OSL methodologies, places it between 300,000 and 400,000 years ago, a period dominated by *Homo heidelbergensis* across Europe [1]. Fossil records from this time in the Iberian Peninsula are primarily represented by individuals from the Atapuerca complex, especially the Sima de los Huesos site (Burgos, Spain), as well as the Bolomor site (Valencia, Spain) and the Aroeira Cave (Almonda, Portugal). While the preservation and conservation of fossils at the Ruidera site are influenced by the material's age, its potential contribution to understanding human evolution in the region is undeniable.

This study focuses on 14 cranial fragments from the paleoanthropological site of Ruidera (Ciudad Real, Spain). Using comparative anatomy of fossil human skulls and virtual anthropology, we differentiated between plesiomorphic characteristics associated with the taxon *Homo erectus* (*sensu lato*) and apomorphic features characterizing the Neanderthal clade. The Ruidera fossils were also compared with Middle Pleistocene specimens, such as those from Kabwe (Zambia), Bodo (Ethiopia), Arago (France), and Petralona (Greece). Our results show that the morphology of the Ruidera fossil fragments fits well into the variability of African Middle Pleistocene specimens. Additionally, the study was complemented by the use of micro-computed tomography (micro-CT), focusing on the most complete fragments recovered from the excavation, including a parietal fragment (RVH-1), a frontal fragment (RVH-11), and two fragments identified as parts of the supraorbital torus (RVH-25 and RVH-43). The ontogenetic analysis revealed significant differences in the degree of mineralization and cranial structure formation [2,3]. Specifically, three clear ontogenetic stages were identified: “child”, “adolescent” and “young adult”. Generally, a greater thickness of the diploë, along with the presence of trabeculae and vascular cavities near the ectocranial membranes throughout the structure, were identified as indicative of advanced growth stages.

Nowadays, the taxonomic identification on the Ruidera site remains unresolved, nevertheless the results have the potential to enhance and enrich the broader narrative of Middle Pleistocene human populations in Southern Europe, highlighting the complexity and regional variability of hominin evolution.

This research is funded by Leakey Foundation project ID: 45148 (2024-2025) entitled “Paleoanthropological investigation at Ruidera-Los Villares: Deciphering Middle Pleistocene Enigma in Western Europe”; and also, by Fundación PALARQ Project entitled “Desvelando la Cronología del Pasado Humano: Análisis Multimétodo de Datación en el Yacimiento de Ruidera-Los Villares, Pleistoceno Medio”. We acknowledge the neighbours and institutions from Ruidera for their hospitality as well as Junta de Comunidades de Castilla-La Mancha and Parque Natural de las Lagunas de Ruidera for awarding the permits for the excavation. We also want to acknowledge the entire excavation team for their great and selfless work.

References: [1] García Martínez, D., Duval, M., Zhao, J., Feng, Y., Wood, R., Huguet, R., Gifuentes-Alcobendas, G., Palancar, C.A., Moya-Maleno, P.R., 2022. Los Villares locality (Ruidera, Castilla-La Mancha, Spain): a new Middle Pleistocene fossil assemblage from the Southern Iberian Plateau with possible evidence of human activity. *Cuaternario y Geomorfología*. 36, 7–35. [2] García Gil, O., Cambra-Moo, O., Audije Gil, J., Nacarino-Meneses, C., Rodríguez Barbero, M.A., Rascón Pérez, J., González Martín, A., 2016. Investigating histomorphological variations in human cranial bones through ontogeny. *Comptes Rendus Palevol*. 15, 527–535. [3] García Gil, O., 2021. Modelado y remodelado en los huesos del neurocráneo (Doctoral dissertation). Universidad Autónoma de Madrid, Madrid, MS. 28049.

Poster Presentation Number 23, Session 1, Thursday 14:00 - 15:30

## Site formation processes in an open-air context in Northern Luangwa Valley (Zambia) using geoarchaeology, chronostratigraphy and hydrological modelling

Ariane Burke<sup>1</sup>, Jan-Pieter Buylaert<sup>2</sup>, Guillaume St-Onge<sup>3</sup>, Matt Peros<sup>4</sup>, Flora Schilt<sup>5</sup>, Maggie Katongo<sup>6</sup>, Joseph Mutele Museba<sup>7</sup>

1 - Université de Montréal, Canada · 2 - Technical University of Denmark · 3 - Université du Québec à Rimouski, Canada · 4 - Bishop's University, Canada · 5 - Vrije Universiteit Amsterdam, Netherlands · 6 - Rice University, USA · 7 - National Heritage Conservation Commission, Zambia

The Luangwa Valley, Zambia, is a lateral extension of the East African Rift system that has received comparatively little archaeological attention despite its strategic geographic position. Initial archaeological exploration of the Luangwa valley was carried out early in the 21<sup>st</sup> Century. Archaeological, geoarchaeological and paleontological fieldwork has subsequently been carried out in the central and southern Luangwa valley, confirming the presence of abundant Stone and Iron Age material in multiple surface deposits and some stratified contexts [1].

Recent archaeological fieldwork was undertaken in the northern Luangwa valley during three short field seasons in 2016, 2019 and 2023. The fieldwork consisted of archaeological surveys, conducted in 2016 and 2019, confirming the existence of several large concentrations of Stone Age lithics in open-air contexts located in the piedmont zone of the Luwumbu and the Viziba sub-basins [2]. One of the largest of these localities, SW23, was the focus of fieldwork in 2019 which included the systematic field collecting of surface material and test excavations. Lithic analyses undertaken subsequently [3] indicated that the collection is dominated by late Early Stone Age/Middle Stone Age material. Geoarchaeological analyses suggested that the archaeological material originates in Quaternary sediments (colluvium and alluvium) reworked by climate-driven changes to the hydrological system and contemporary erosion processes. The nature of site formation processes at SW23 was only imperfectly understood and the chronology of the site remained uncertain, however. Further chronological sampling was undertaken at SW23 in 2023 and the luminescence-based chronostratigraphy of the lithic concentration at SW23 is the focus of this paper. We use a combination of chronostratigraphy, geoarchaeological analyses and hydrological modelling to reconstruct site formation processes, improve our understanding of the nature of the lithic concentration and refine the chronological attribution suggested on the basis of lithic typology.

The authors gratefully acknowledge Michael Bisson, who instigated fieldwork in northern Luangwa in 2016 and 2019. Steve Toland (Chipembele Wildlife Education Trust) provided invaluable assistance to the project. Fieldwork in 2023 was made possible by a grant from the GEOTOP Research Centre in Earth System Dynamics, Canada (GEOTOP-25-2023).

References: [1] Colton, D., Whitfield, E., Plater, A.J., Duller, G.A.T., Jain, M., Barham, L., 2021. New geomorphological and archaeological evidence for drainage evolution in the Luangwa Valley (Zambia) during the Late Pleistocene. *Geomorphology*. 392, 107923. [2] Burke, A., Bisson, M., Schilt, F., Tolan, S., Museba, J., Drapeau, M.S.M., Aleman, J.C., Peros, M.C., 2023. The archaeological potential of the northern Luangwa Valley, Zambia: The Luwumbu basin. *PLOS ONE*. 18, e0269209. [3] Bisson, M.S., Burke, A., Schilt, F., Aleman, J., Peros, M.C., Drapeau, M., Katongo, M., Kayuni, M.N., Museba, J.M., Tolan, S., 2024. Sitwe 23, a Complex ESA/MSA Locality in the Northern Luangwa Valley, Zambia. *African Archaeological Review*. 41, 163–203.

Poster Presentation Number 24, Session 1, Thursday 14:00 - 15:30

## From glass to stone: examining flake dynamics through fracture mechanics under the shadow of the Oldowan

Guillermo Bustos-Pérez<sup>1,2,3</sup>, Shannon Patrick McPherron<sup>1</sup>

1 - Departament of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig · 2 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain · (3) Universitat Rovira i Virgili, Departament d'Història i Història de l'Art, Tarragona, Spain

African Oldowan lithic assemblages date to at least 2.6 Ma, and persist through their co-occurrence with the earliest Acheulean industries circa 1.7 Ma. The Oldowan consists mainly of flaked cobbles and their corresponding flakes, which likely were used mainly for cutting activities. Because of its simplicity and long duration through different geographical and environmental contexts, the Oldowan is considered a relatively static technology; however, there is some variability that likely has a chronological component [1]. As the earliest evidence of systematic flake production, the Oldowan has been subject to debates regarding the technical skills of early stone tool makers, their understanding of which aspects of knapping control flake shape and size, and whether this understanding changed over the course of the Oldowan [2].

Controlled experiments [3] have provided insights into how knappers can vary key aspects of the knapping process to alter flake shape and size. In particular, these experiments have showed that platform depth, external platform angle, and angle of blow have a large effect on flake shape and size. Experiments with expert knappers have shown that they can optimize these attributes in order to obtain larger flakes [4]. Controlled experiments have mainly used plate glass or rather idealized cuboid core shape made of glass. In the latter, the main flaking surface is slightly domed and elongated, somewhat like Levallois cores. These cores have allowed for standardized replicable experiments on the drivers of flake formation, size and morphology while producing flakes that are comparable to ones found in the archaeological record. It is, however, unclear whether these findings are generalizable to the kinds of pebble core morphologies characteristic of the Oldowan.

Here we report on an on-going effort to expand the previous controlled experiments into a very different core morphology and one that more closely resembles the rounded pebbles characteristic of much of the early Oldowan and initial systematic flake production. We use glass hemispheres of different sizes, and flake them with varying platform depths and angles of blow (0 and 20 degrees) employing the same apparatus from the Dibble and colleagues experiments [3]. The original Dibble set-up was modified by printing 3D the core holders, allowing to more precisely control angle of blow (each holder having a fixed angle). Due to the convex structure of the glass hemisphere cores, the exterior platform angle is not an independent variable and it is also not easily measured, varying constantly across the flaking surface of the hemisphere cores (contrasting with the Dibble designed cores which had an easily modifiable and measurable exterior platform angle).

With this setup over 100 flakes have been produced. Results support the previously observed tradeoff between platform depth, angle of blow, force needed for detachment and flake length. Increasing the platform depth results in longer, heavier flakes, while increasing the angle of blow results in shorter, lighter flakes which require less force to be extracted. When the external platform angle of flakes from hemisphere cores was estimated using the Dibble and colleague's dataset, predictions of flake mass and morphology improved. This result reinforces the value of external platform angle together with platform depth and angle of blow as driving features of flake shape and size. Additionally, it shows that the flake model derived from the Dibble and colleagues experiments can be generalized to additional core morphologies. It can also be inferred that skilled knappers can modify platform depth and angle of blow in order to obtain similar flake and edge length values with less required force.

References: [1] Braun, D.R., Aldeias, V., Archer, W., Arrowsmith, J.R., Baraki, N., Campisano, C.J., Deino, A.L., DiMaggio, E.N., Dupont-Nivet, G., Engda, B., Feary, D.A., Garello, D.I., Kerfelew, Z., McPherron, S.P., Patterson, D.B., Reeves, J.S., Thompson, J.C., Reed, K.E., 2019. Earliest known Oldowan artifacts at ~2.58 Ma from Ledi-Geraru, Ethiopia, highlight early technological diversity. *Proceedings of the National Academy of Sciences*. 116, 11712–11717. [2] Toth, N., Schick, K., 2018. An overview of the cognitive implications of the Oldowan Industrial Complex. *Azania: Archaeological Research in Africa*. 53, 3–39. [3] Dibble, H.L., Rezek, Z., 2009. Introducing a new experimental design for controlled studies of flake formation: results for exterior platform angle, platform depth, angle of blow, velocity, and force. *Journal of Archaeological Science*. 36, 1945–1954. [4] Nonaka, T., Bril, B., Rein, R., 2010. How do stone knappers predict and control the outcome of flaking? Implications for understanding early stone tool technology. *Journal of Human Evolution*. 59, 155–167.

Poster Presentation Number 25, Session 1, Thursday 14:00 - 15:30

## Altamura (southern Italy): the first description of the inner structures of a Neanderthal nasal cavity

Costantino Buzi<sup>1</sup>, Antonio Profico<sup>2</sup>, Carlos Lorenzo<sup>3,4</sup>, Giorgio Manzi<sup>5</sup>

1 - DFG Center for Advanced Studies “Words, Bones, Genes, Tools”, Department of Geosciences, University of Tübingen, Tübingen, Germany · 2 - Department of Biology, University of Pisa, Pisa, Italy · 3 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain · 4 - Departament d’Història i Història de l’Art, Universitat Rovira i Virgili, Tarragona, Spain · 5 - Department of Environmental Biology, Sapienza University of Rome, Rome, Italy

The adaptation of Neanderthals to extreme climatic conditions is a topic of significant interest in paleoanthropology. Predictably, researchers have focused extensively on the nasal region, which is also particularly distinctive in *Homo neanderthalensis* [1]. Nevertheless, studies have been limited by the scarcity of preserved bony nasal structures in the human fossil record, especially the internal ones. In this study, we present and analyze the complete inner nasal structures of an early Neanderthal skeleton from Altamura, southern Italy. This exceptional specimen was discovered in October 1993 during a speleological survey of a newly identified karst system northeast of Altamura in the Apulia region, and has been dated (U-Th) to the late Middle Pleistocene (between  $172 \pm 15$  and  $130.1 \pm 1.9$  ka) [2]. The nearly complete skeleton is situated within a niche inside a very small chamber of the karstic system, covered with characteristic concretions and coatings of varying thickness, which represent one of the reasons that continue to hinder the removal of the fossil from the cave, allowing only for on-site analyses [3]. The extraordinary preservation of the specimen makes it possible to study structures absent in the entire human fossil record, such as those of the nasal cavity, providing previously unavailable evidence for the Neanderthals. Most importantly, the structures observed in Altamura settle a longstanding debate about some inner nasal traits proposed as autapomorphies of the species *Homo neanderthalensis* in relationship to cold climate [4]. With these premises, we reconstructed a 3D model of the nasal cavity from this specimen. We compared it with the available samples from modern human populations from various geographic regions, each characterized by distinct climatic adaptations. Our observations point to an indirect influence of climatic adaptations on the Neanderthal midface, in the absence, however, of specific adaptations of the internal nasal structures exclusive to *Homo neanderthalensis*.

We thank the local authorities Soprintendenza A.B.A.P. per la c.m. di Bari (Luigi La Rocca, Francesca Radina, and Elena Dellù), Parco Nazionale dell’Alta Murgia and the municipality of Altamura; the speleologists of the C.A.R.S.; Olympus Italia S.r.l. (Marco Antonucci), Olympus Europe (Stefano Tamburrini); Maria Dolors Guillen Espínola (IPHES-CERCA); all the participants to the project “KARST” (PRIN 2015WPHSCJ).

References: [1] Márquez, S., Pagano, A.S., Delson, E., Lawson, W., Laitman, J.T., 2014. The Nasal Complex of Neanderthals: An Entry Portal to their Place in Human Ancestry. *The Anatomical Record*. 297, 2121–2137. [2] Profico, A., Buzi, C., Di Vincenzo, F., Boggioni, M., Borsato, A., Boschian, G., Marchi, D., Micheli, M., Cecchi, J.M., Samadelli, M., Tafuri, M.A., Arsuaga, J.L., Manzi, G., 2023. Virtual excavation and analysis of the early Neanderthal cranium from Altamura (Italy). *Communications Biology*. 6. [3] Buzi, C., Boggioni, M., Borsato, A., Boschian, G., Marchi, D., Moggi-Cecchi, J., Profico, A., Riga, A., Samadelli, M., Manzi, G., 2024. Virtual paleoanthropology in karstic environments. The challenging case of the Neanderthal skeleton from Altamura (southern Italy). *Quaternary Science Reviews*. 338, 108833. [4] Schwartz, J.H., Tattersall, I., 1996. Significance of some previously unrecognized apomorphies in the nasal region of *Homo neanderthalensis*. *Proceedings of the National Academy of Sciences*. 93, 10852–10854.

Poster Presentation Number 26, Session 0, day 00:

## The SD-1219 Neanderthal skull in the context of cerebellar evolution

**María Asunción Cabestrero-Rincón<sup>1</sup>, Frederick Coolidge<sup>2</sup>, Costantino Buzi<sup>3</sup>, Cedric Boeckx<sup>4,5,6,7</sup>**

1 - Human Evolution and Cognition Group (EvoCog), University of the Balearic Islands, Palma, Spain; · 2 - Center for Cognitive Archaeology, University of Colorado, Colorado Springs, USA · 3- DFG Center for Advanced Studies “Words, Bones, Genes, Tools”, University of Tübingen, Germany · 4 - ICREA (Catalan Institute for Advanced Studies and Research) · 5 - Universitat de Barcelona, Section of General Linguistics · 6 - Institute of Neurosciences, Universitat de Barcelona · 7 - Universitat de Barcelona Institute for Complex Systems (UBICS)

The cerebellum appears to be a locus of divergence between us and our closest extinct relatives. Its differential growth has been hypothesized to have contributed to our distinctive skull shape and brain organization underlying our sociability and important aspects of cognition, particularly creativity and innovation [1]. Due to the worldwide scarcity of Neanderthal occipital bones with a preserved cerebellar area, even a single specimen constitutes a significant addition. Here we present a reconstruction and analyses of SD-1219 Neanderthal from the El Sidrón karst system, a cave site located in Asturias, Spain, and dated  $\sim 48,400 \pm 3200$  yBP [2].

We performed a virtual reconstruction adopting the principles of biological symmetry, according to the models of Gunz et al. [3] and others. The endocranial descriptions of Rosas et al. [4] also pointed in the same direction, as they observed wide cerebellar fossae but no asymmetry in this area. We followed part of the reconstruction procedure proposed by Bastir et al. [5]. We used the SlicerMorph package to create mirror images of SD-1219. We developed a mean sagittal best fit curve with a semi-landmark (sLM) outline, which was subsequently used in the Morpho R package to complete the right side. The adequacy of the SD-1219 reconstruction was tested using four Neanderthal specimens (La Ferrassie 1, La Chapelle aux Saints 1, Saccopastore 1, Salzgitter 1), a group with clear Neanderthal morphologies. Each specimen was treated as the target specimen, so the others were deformed relative to it, slid, and projected ten times reciprocally, and to the group consensus. A geometric morphometric analysis of the cerebellar area was performed in Evan ToolBox with 6 landmarks - left and right endasterion, endinion, opisthion, and left and right cerebellar depth - and 324 semilandmarks, to verify the influence of each specimen on the overall sample, which comprised 5 Neanderthals and 61 *Homo sapiens* (fossil, early Holocene, and extant). We repeated five times a generalized Procrustes analysis (GPA) with and without SD-1219 and with any other Neanderthal specimens, performed by optimally translating, rotating and uniformly scaling the specimens, followed by a Principal Component analysis (PCA).

PC1 separates extant *H. sapiens* from the other groups, while on PC2 early Holocene and fossil *H. sapiens* appear closer on one side, the Neanderthal group on the other side, and extant humans are located near the middle configuration. Although the areas in which each group differs from extant humans remain to be mapped in detail, we observed subtle but significant differences between Neanderthals and *Homo sapiens*, the most salient one being that Neanderthals show slightly protruding right cerebellar fossae, whereas ancient fossil *H. sapiens* cerebelli are particularly prominently expanded in certain small areas on the left side. The early Holocene specimens show little expansions in the left side too, but not in the same areas.

All these small differences likely point to the lateral and posterior portions of the cerebellum, so they could be related to the recent evolution of this organ, which is connected to other lobes throughout the brain.

We especially thank Dr. Antonio Rosas for the fossil SD-1219, and the curators and institutions for the other specimens.

References: [1] Coolidge, F.L., 2021. The role of the cerebellum in creativity and expert stone knapping. *Adaptive Behavior*, 29, 1-13. [2] Wood, R.E., Higham, T. F. G., De Torres, T., Tisnérat-Laborde, N., Valladas, H., Ortiz, J.E., Lalueza-Fox, C., Sánchez-Moral, S., Cañaveras, J.C., Rosas, A., Santamaria, D., De La Rasilla, M., 2012. A New Date for The Neanderthals From El Sidrón Cave (Asturias, Northern Spain). *Archaeometry*. 55, 148–158. [3] Gunz, P., Mitteroecker, P., Neubauer, S., Weber, G.W., Bookstein, F.L., 2009. Principles for the virtual reconstruction of hominin crania. *Journal of Human Evolution*. 57, 48–62. [4] Rosas, A., Peña-Melián, A., García-Tabernero, A., Bastir, M., De La Rasilla, M., Fortea, J., 2008. Endocranial Occipito-Temporal Anatomy of SD-1219 from the Neandertal El Sidrón Site (Asturias, Spain). *The Anatomical Record*. 291, 502–512. [5] Bastir, M., Rosas, A., Tabernero, A.G., Peña-Melián, A., Estalrich, A., de la Rasilla, M., Fortea, J., 2010. Comparative morphology and morphometric assessment of the Neandertal occipital remains from the El Sidrón site (Asturias, Spain: years 2000–2008). *Journal of Human Evolution*. 58, 68–78.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Oral pathologies among early hominins from Eastern Africa (Kenya): new cases and evolutionary implications

Edgard Camarós<sup>1</sup>, Marta Mirazón-Lahr<sup>2</sup>

1 - Department of History (Prehistory) and CISPAC, Universidad de Santiago de Compostela · 2 - Leverhulme Centre for Human Evolutionary Studies, Department of Archaeology, University of Cambridge

Our biological and social interaction with disease has been a major evolutionary factor shaped by dynamic immune responses and environmental conditions through time. However, preservation conditions of the early hominin fossil record poses challenges in the identification of pathological conditions, especially in the post-cranial skeleton. In contrast, dental remains are better preserved and higher in number, making oral pathology a valuable proxy to approach hominin-disease interaction, potentially reflecting stress and health conditions, but also dietary and social behaviour in early hominin evolution [1].

Here, we discuss and diagnose the oral pathologies, specifically dento-alveolar lesions, observed among early hominins from Eastern Africa curated at the National Museum of Kenya in Nairobi and the Turkana Basin Institute in Turkwel, Kenya. Specimens analysed include australopithecines, *Homo erectus* and *Homo sapiens* from East and West Turkana. Identified pathologies among the fossil record include infections (e.g., carious lesions), periapical lesions, abscesses, ante-mortem tooth loss (although not strictly a pathology, rather a consequence of it) and chippings. Pseudopathologies - taphonomic damage mimicking disease - are also addressed as limitations in the characterisation and as part of the differential diagnosis.

Using a macro- and microscopic analytical approach, our findings show a notable prevalence of oral pathologies among early hominins in East Africa, echoing patterns observed in South African fossil hominins [2,3]. While many lesions are prevalent throughout human evolution [4,5], the oral anatomical distribution may offer differential traits and insights when compared with pre-agricultural and agricultural groups, suggesting a link between oral pathologies and biological and social evolutionary factors. Given the osteological assemblage available, pathologies were not linked to sex, but positively to age. Comparisons with oral diseases in wild and captive non-human primates (i.e., gorillas) suggest a similar pathogenesis, modulated by differences in craniofacial anatomy (maxillary and mandibular alveolar regions).

In sum, oral pathology provides a unique lens for exploring biological and social evolution in early hominins. Despite preservation-related limitations, contextualizing these findings within an evolutionary framework - considering diet, environment, and behaviour - provides key insights into past lifestyles.

The research is funded by projects PID2023-149059NA-I00 (AEI, Spain) and NG'IPALAJEM (ERC 101020478). EC is beneficiary of a Ramón y Cajal Research Grant (RYC2021-031120-I).

References: [1] Hillson, S., 2014. Tooth development in human evolution and bioarchaeology. Cambridge University Press. [2] Grine, F.E., Gwinnett, A.J., Oaks, J.H., 1990. Early hominid dental pathology: Interproximal caries in 1.5 million-year-old *Paranthropus robustus* from Swartkrans. Archives of Oral Biology. 35, 381–386. [3] Towle, I., Irish, J.D., De Groote, I., Fernée, C., Loch, C., 2021. Dental caries in South African fossil hominins. South African Journal of Science, 117. [4] Smith, T.M., Warinner, C., 2022. Developmental, evolutionary, and behavioural perspectives on oral health. Palaeopathology and evolutionary medicine: an integrated approach, 95-120. Oxford University Press. [5] Pandiani, C.D., Suby, J., Millán, G., Novellino, P., 2025. Dento-Alveolar Infectious Diseases Among Hunter-Gatherers from Northeast and Central Chubut Province (Argentina) during the Late Holocene. International Journal of Osteoarchaeology.

Poster Presentation Number 27, Session 1, Thursday 14:00 - 15:30

## The role of the green Sahara in human evolution

Miguel Caparros<sup>1</sup>

1 - UMR 7194 « Histoire naturelle de l'Homme préhistorique » CNRS-MNHN-UPVD Alliance Sorbonne Université, Musée de l'Homme, Paris

The rock art of the Sahara is testimony of the transformation of this hyperarid desert into a humid paleo-environment and green landscape sprinkled of gigantic lakes during the Holocene. Was this recent humidification a unique event, or did the greening of the Sahara reoccur multiple times and became an episodic dispersal route out of Africa of humans from Subsaharan Africa into North Africa, Western Asia and Europe during the Pleistocene? We present the findings of multidisciplinary research we conducted to elucidate whether the Sahara was a barrier to migration [1].

During the Holocene, the five styles of rock art identified in central Sahara (Bubalin-Large african fauna, Têtes rondes, Bovidian, Caballin and Camelin) follow the changes of ecosystems affected by the northward migration of the West African summer monsoon and its subsequent southward shift. Analyses of run-offs of the Nile and Niger rivers, fluctuations in lake shore levels in central Sahara, and Atlantic deep offshore sampling of pollens and terrigenous deposits, confirm the existence of a progressive humid period in the Sahara from 15 to 5 ka BP interspersed with small intervals of dessication and a peak of humidity at around 9 ka. Archaeological studies confirm the advent of a progressive pastoral culture in the Sahara as reflected in the rock art further to the Neolithic revolution that took place in the Near East. The main cause of the humidification of the Sahara during the Holocene is the northward shift of the Intertropical Convergence Zone (ITCZ) linked to the glacial-interglacial instability in northern latitudes, changes of insolation and variations of atmospheric conditions in the West Atlantic.

Was the mid-Holocene green Sahara preceded by further wet periods during the Pleistocene? Continental and marine paleo-climatic studies confirm the existence of numerous humid periods during the Pleistocene, particularly from the analysis of sapropels (blackish sediments rich in organic matter deposited in the Ionian Sea further to large run-offs of the river Nile linked to increased pluvial intensity in East Africa and the Sahara). If one uses sapropels as proxies of humid periods in the Sahara, such wet events would have occurred 28 times over the last 1.2 Ma. Humid periods in the Sahara translate into a green ecosystem covered by savannas and steppes, littered of lakes (some gigantic like the Mega-Tchad and Mega-Fezzan), with aquatic corridors allowing the passage of human groups. The human presence in the Sahara during the Pleistocene is supported by numerous archaeological sites throughout its extension, with lithic industries ranging from Oldowayan, Acheulean up to Middle Palaeolithic techno-complexes like Mousterian and Aterian. This human presence most probably occurred during humid periods, considering that there are no Upper Palaeolithic sites in the Sahara connected with the last hyperarid MIS 2 glacial period.

We propose a model of arid-humid-arid cycles that illustrates the ecosystem changes during a full cycle of glacial to interglacial back to glacial periods in the Sahara, and show that during periods of extreme aridification, North Africa must have acted as refugia to human groups that had migrated during humid periods from Subsaharan Africa. The numerous alternating closing and reopening phases of the Sahara during the Pleistocene probably led to multiple events of genetic exchanges between isolated human groups of North Africa and Subsaharan Africa, which would favor a reticulate mode of evolution of the genus *Homo* leading up to the emergence of *Homo sapiens* [2]. We conclude by showing a comparative chronology of the various species of the genus *Homo* with an index of periodic African wet-dry phases, and present suggestions of further research in palaeoanthropology that would take into consideration paleo-climatic factors in East Africa and the Sahara.

References: [1] Caparros, M., 2022. Le rôle du Sahara dans l'évolution humaine en périodes humides, lorsqu'il n'était pas un désert, In: Djindjian F. (Ed.), Les sociétés humaines face aux changements climatiques, UISPP, 2, p. 189-223, Archaeopress Archaeology [2] Caparros, M. and Prat, S., 2021. A phylogenetic networks perspective on reticulate human evolution. *iScience* 24, 102359.

Poster Presentation Number 28, Session 1, Thursday 14:00 - 15:30

## A landscape approach to low-visibility archaeology: modeling site formation in capuchin stone tool use

Meredith K.W. Carlson<sup>1</sup>, Tamara Dogandzic<sup>2</sup>, Brendan Barrett<sup>3</sup>, Nicolas Zwyns<sup>4</sup>

1 - University of California, Davis · 2 - Leibniz-Zentrum für Archäologie · 3 - Max Planck Institute of Animal Behavior · 4 - Université de Bordeaux

Our understanding of the earliest lithic record is limited by constraints on site and artifact visibility. The dilemma of identifying early, potentially unmodified tools has persisted since it was raised by Panger and colleagues [1]. The study of percussion tool use by nonhuman primates provides the opportunity to address some of these concerns. Primate percussion shares important commonalities with the Lomekwian [2] and the early Oldowan at Nyayanga [3], both of which contain a significant percussion element within the assemblages. The unmodified hammer-and-anvil toolkits used by nonhuman primates exhibit low, but present, archaeological visibility, providing a parallel with the observed and hypothesized early hominin record [4]. The unmodified hammerstones used in simple percussion technology are unlikely to be definitively identifiable on an individual basis. One important avenue for resolution is the landscape approach, which provides more opportunities for identification [5].

Here, we report on efforts to document and model site formation and taphonomy among white-faced capuchin (*Cebus capucinus imitator*) tool-users in Coiba National Park, Panama. Sites produced by capuchins include conspicuous midden-like accumulations of food debris and hammerstones, which have distinctly high visibility on a multi-year scale. Between 2021 and 2024, we surveyed sites with a visible record of percussion tool use (n=528) on the islands of Coiba and Jicarón, establishing the viability of studying these tool use locales through an archaeological lens. This included survey of 63 higher-visibility midden sites. In 2022, we conducted two site formation experiments, collecting both archaeological proxies and video-recorded observations of behavior, which could be temporally linked. We examine how this paired approach may help validate or challenge archaeological proxies.

Our results provide validation that large midden-like sites are associated with intense periods of percussion tool use. Preliminary results from the comparison of archaeological and behavioral metrics suggest that in some circumstances, archaeological proxies are more sensitive in detecting site use intensity than behavioral observation via camera trapping. We found that the MNI of processed nuts (779) overestimated the activity at one of the experimental sites when compared to the number of tool use episodes recorded on camera (750). However, the relationship between archaeological and behavioral estimates of site use is not consistent across periods and sites, indicating the potential importance of non-behavioral landscape factors in determining the archaeological visibility of percussion tool use. To that end, we also present a spatially explicit model of midden site formation in specific physical environments. This work provides clarification of the processes involved in the (in)visibility of assemblages associated with unmodified tool use, with implications for identifying a broader range of technological undertakings in the hominin record.

We thank the Ministerio de Ambiente, Panama for relevant permitting and the Smithsonian Tropical Research Institute for support of this project. Major funding was provided by a Leakey Foundation grant and the Max Planck Institute.

References: [1] Panger, M.A., Brooks, A.S., Richmond, B.G., Wood, B., 2002. Older than the Oldowan? Rethinking the emergence of hominin tool use. *Evolutionary Anthropology: Issues, News, and Reviews*. 11, 235–245. [2] Harmand, S., Lewis, J.E., Feibel, C.S., Lepre, C.J., Prat, S., Lenoble, A., Boës, X., Quinn, R.L., Brenet, M., Arroyo, A., Taylor, N., Clément, S., Davaer, G., Brugal, J.-P., Leakey, L., Mortlock, R.A., Wright, J.D., Lokorodi, S., Kirwa, C., Kent, D.V., Roche, H., 2015. 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. *Nature*. 521, 310–315. [3] Harmand, S., Arroyo, A., 2023. Linking primatology and archaeology: The transversality of stone percussive behaviors. *Journal of Human Evolution*. 181, 103398. [4] Proffitt, T., Haslam, M., Mercader, J.F., Boesch, C., Luncz, L.V., 2018. Revisiting Panda 100, the first archaeological chimpanzee nut-cracking site. *Journal of Human Evolution*. 124, 117–139. [5] Pascual-Garrido, A., Carvalho, S., Almeida-Warren, K., 2023. Primate archaeology 3.0. *American Journal of Biological Anthropology*. 183.

Poster Presentation Number 29, Session 1, Thursday 14:00 - 15:30

## Rabbit exploitation in the Middle Paleolithic: insights from experimental archaeology applied to Iberian Middle Paleolithic faunal assemblages

Milena Carvalho<sup>1</sup>, Cristina Real<sup>2,3</sup>, Anna Rufà<sup>1,4</sup>, Leopoldo Pérez<sup>5,6</sup>, Jonathan Haws<sup>1,7</sup>, Alfred Sanchis<sup>8</sup>

1 - Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour, Universidade do Algarve, Faro, Portugal · 2 - Departamento de Prehistoria, Arqueología e Historia Antigua, Universidad de Valencia, Valencia, Spain · 3 - Grupo de Investigación PREMEDOC, Universitat de València, València, Spain · 4 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, F-33600 Pessac, France · 5 - Área de Prehistoria, Departamento de Geografía e Historia, Facultad de Humanidades, Universidad de La Laguna, Campus de Guajara, San Cristóbal de La Laguna, Spain · 6 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain · 7 - Dept. of Anthropology, University of Louisville, KY, USA · 8 Museu de Prehistòria de València, Servei d'Investigació Prehistòrica (SIP), Diputació de València, Valencia, Spain

The archaeological record from southwestern Europe—particularly the Iberian Peninsula and southern France—demonstrates the persistent inclusion of small prey, especially Leporidae, in the subsistence strategies of both Neanderthals and anatomically modern humans during the Middle and Upper Paleolithic. Although rabbits frequently appear in faunal assemblages, their role in the human diet remains understudied. This is partly because small prey can be disarticulated by hand, often leaving few of the bone surface modifications typically used to infer human activity. Moreover, the potential for warren-hunting and mass capture strategies raises important questions about opportunism versus selection of this prey item and how different cooking or preservation methods might be reflected—or go undetected—in the archaeological record. In particular, the techniques used to process and preserve leporids require further experimental study, as their ecology, size, and nutritional yield likely necessitated distinct culinary and logistical strategies. Addressing this gap is crucial for reconstructing the full range of human adaptive behaviors.

This study presents the results of an experimental program designed to evaluate how three cooking and preservation methods—roasting, smoking, and drying—affect the taphonomic signatures of rabbit bones. Eight specimens were prepared using each method, disarticulated and defleshed by hand and with experimentally replicated lithic tools. The resulting assemblages were subjected to taphonomic analysis, including assessments of fracture patterns, burning, and surface modifications. These data were compared to archaeological rabbit assemblages from Middle Paleolithic sites across the Iberian Peninsula, including Lapa do Picareiro, Abrigo de la Quebrada, Cova Negra and Cova de les Malladetes, and others. These sites exhibit varying degrees of anthropogenic modification, providing a valuable comparative framework. The results establish a reference collection for identifying cooking and preservation traces on small prey remains, enabling more nuanced interpretations of leporid exploitation. This research contributes to broader discussions of delayed consumption, resource intensification, opportunism versus selectivity, and mobility strategies, ultimately advancing our understanding of behavioral variability in Paleolithic Europe.

We would like to thank Juan Pablo Donadei Corada for reproducing the lithic tools used in the experiment. The Project "La dieta de neandertales y sapiens. Evaluación experimental del procesado de los conejos y su calidad alimenticia (LEO23-2-9659)", supported by a 2023 Leonardo Grant for Researchers and Cultural Creators, BBVA Foundation. The BBVA Foundation accepts no responsibility for the opinions, statements and contents included in the project and/or the results thereof, which are entirely the responsibility of the authors. C. Real, A. Rufà, M. Carvalho and J. Haws are part of the CIGE/2023/5 (Conselleria de Educación, Cultura, Universidades y Empleo, Generalitat Valenciana, Conselleria de Educación, Cultura, Universidades y Empleo). C. Real and A. Sanchis are part of the PID2021-122308NA-I00 project funded by MCIN/AEI/10.13039/501100011033/ and FEDER Una manera de hacer Europa. A. Rufà is currently a beneficiary of a CEEC - 3rd Edition research contract promoted by the Portuguese FCT (reference: 2020. 00877.CEECIND), and is part of the Spanish MICINN project PID2022-138590NB-C41, the Generalitat de Catalunya projects CLT009/22/000045, CLT009/22/00044 and CLT009/22/00024, and the and the PCR « paléocologie du Lazaret», funded by the Drac Provence- Alpes-Côte d'Azur. M. Carvalho is currently a beneficiary of a CEEC - 5th Edition research contract promoted by the Portuguese FCT (reference: 2022. 06405.CEECIND). L. Pérez is supported by a postdoctoral contract funded by the University of La Laguna, "La Caixa" Banking Foundation and the "Cajacanarias" Banking Foundation.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## The Boomerang of Obłazowa recalibrated: a multidisciplinary study redefining Central Europe's earliest complex toolmaking

Nicole Casaccia<sup>1</sup>, Paweł Valde-Nowak<sup>2</sup>, Michael P. Richards<sup>3</sup>, Lukas Wacker<sup>4</sup>, Laura Tassoni<sup>1</sup>, Adam Nadachowski<sup>5</sup>, Anna Kraszewska<sup>2</sup>, Magda Kowal<sup>2</sup>, Jakub Skłucki<sup>2</sup>, Christopher Barrington<sup>6</sup>, Monica Kelly<sup>6</sup>, Frankie Tait<sup>7</sup>, Mia Williams<sup>6</sup>, Carla Figus<sup>8</sup>, Antonino Vazzana<sup>8</sup>, Ginevra Di Bernardo<sup>8</sup>, Matteo Romandini<sup>8</sup>, Giovanni Di Domenico<sup>9</sup>, Stefano Benazzi<sup>8</sup>, Cristina Malegori<sup>10</sup>, Giorgia Sciutto<sup>1</sup>, Paolo Oliveri<sup>10</sup>, Jean-Jacques Hublin<sup>11,12</sup>, Mateja Hajdinjak<sup>13</sup>, Pontus Skoglund<sup>6</sup>, Andrea Picin<sup>1</sup>, Sagra Talamo<sup>1</sup>

1 - Department of Chemistry G. Ciamician, University of Bologna, Bologna, Italy · 2 - Institute of Archaeology, Jagiellonian University, Kraków, Poland · 3 - Department of Archaeology, Simon Fraser University, Burnaby, B.C., Canada · 4 - Laboratory for Ion Beam Physics, ETH Zurich, Zurich, Switzerland · 5 - Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland · 6 - Ancient Genomics Laboratory, Francis Crick Institute, London, United Kingdom · 7 - Department of Archaeology, University of Reading, Reading, United Kingdom · 8 - Department of Cultural Heritage, University of Bologna, Ravenna, Italy · 9 - Department of Physics and Earth Sciences, University of Ferrara, Ferrara, Italy · 10 - Department of Pharmacy, University of Genova, Genova, Italy · 11 - Collège de France, Paris, France · 12 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 13 - Department of Evolutionary Genetics, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

The beginning of the Upper Palaeolithic (ca. 50,000 to 30,000 years ago) marks a turning point in human evolution, with the arrival of *Homo sapiens* in Europe and the earliest evidence of behavioural modernity. Among these innovations, the Aurignacian attests not only the crafting of personal ornaments, but also a wider range of symbolic artefacts and advanced tools, reflecting enhanced cognitive abilities and cultural complexity [1].

A remarkable example of such technological development is the mammoth ivory boomerang from layer VIII of Obłazowa Cave, Poland, found in association with a human phalanx [2]. The artifact was discovered in good state of preservation and directly dated 18,160 ± 260 BP [3]. However, the reliability of this anomalously young age has been questioned due to the absence of other Late Upper Palaeolithic artefacts in the same context, raising concerns about potential contamination from conservation treatments. This exceptional find offers key insights into the technical skills and mental advancement of *Homo sapiens* in shaping these peculiar and technically complex tools.

This study fills a critical gap by producing the first reliable chronology of the cultural context of layer VIII, through a multidisciplinary approach that involves several animal bones and the human fossil located nearby the boomerang. Thirteen faunal bone samples and the associated human phalanx were analysed using a combination of cutting-edge methods, including ancient DNA analysis, Near-Infrared (NIR) spectroscopy with hyperspectral imaging (HIS) [4], zooarchaeological mass spectrometry (ZooMS), stable isotope analysis and high-resolution radiocarbon dating supported by Bayesian modelling. This strategy also allowed for indirect dating of the mammoth tusk artefact while preserving its physical integrity.

The obtained chronological data suggest a significantly older human occupation phase of the site, between 42,810–38,550 cal BP (95.5% probability), with the boomerang likely dating 42,290–39,280 cal BP (95.5% probability). These results place the Obłazowa boomerang among the oldest known examples of this type of complex tool in Europe and highlight the advanced technical and cognitive abilities of early modern humans in all Central Europe.

In addition to the archaeological implications, this research showcases the power of interdisciplinary methods in helping our understanding of early *Homo sapiens* behaviour, offering new perspectives on Upper Palaeolithic cultural evolution.

This work has been supported by FARE (Framework per l'attrazione ed il rafforzamento delle eccellenze per la Ricerca in Italia - III edizione). "Evaluate the precision of time in Human Evolution adopting spectrometric methods for archaeological bones – EURHOPE" Prot. R20L4N7MS5 CUP J53C2200374000 (awarded to ST); the Italian grant PRIN20209LLK8S\_001 DYNASTY: "Neanderthals dynamic pathway and resilience in central Europe through the chronometric sustainability" funded by the Ministry of University and Research (awarded to ST); European Research Council under the European Union's Horizon 2020 Research and Innovation Programme (grant agreement No. 803147 RESOLUTION, awarded to ST); National Science Center, project no. 2021/41/B/HS3/03217: "The Stone Age Man in the Caves of the Tatra Mountains" (awarded to PVN).

References: [1] Picin, A., Stefański, D., Cieśla, M., Valde-Nowak, P., 2023. The Beginning of the Early Upper Paleolithic in Poland. *Journal of Paleolithic Archaeology*. 6. [2] Valde-Nowak, P., Nadachowski, A., Wolsan, M., 1987. Upper Palaeolithic boomerang made of a mammoth tusk in south Poland. *Nature*. 329, 436–438. [3] Housley, R.A., 2003. Radiocarbon dating. In: Valde-Nowak, P., Nadachowski, A., Madeyska, T., (Eds.), *Obłazowa Cave: Human Activity, Stratigraphy and Palaeoenvironment*, Institute of Archaeology and Ethnology, Polish Academy of Sciences, Krakow, p. 81–85. [4] Malegori, C., Sciutto, G., Oliveri, P., Prati, S., Gatti, L., Catelli, E., Benazzi, S., Cercatillo, S., Paleček, D., Mazzeo, R., Talamo, S., 2023. Near-infrared hyperspectral imaging to map collagen content in prehistoric bones for radiocarbon dating. *Communications Chemistry*. 6.

Poster Presentation Number 30, Session 1, Thursday 14:00 - 15:30

## The relative timing of life history and neurodevelopment shapes the human adaptive niche

Paola Cerrito<sup>1</sup>, Judith M. Burkart<sup>1</sup>

1 - Institute of Evolutionary Anthropology, University of Zurich, Zurich

Human neurodevelopment closely follows patterns observed in primates and other mammals. Early stages such as the formation of neurons, growth of axons, creation of synapses, and the assembly of neural circuits - as well as the onset of initial behaviors - occur in a consistent, step-by-step manner across a wide range of mammals [5]. In contrast, life history events like birth and weaning vary in timing relative to brain maturation. Indeed, birth and weaning have a much lower phylogenetic signal [2], and in humans they happen relatively early, placing infants in a distinctive developmental context where much of their prolonged brain development occurs independently of constant maternal contact [3]. Brain development is experience-dependent: it is affected by the stimuli received during early life [4]. These stimuli differ between late-weaned independently breeding species and early-weaned cooperatively breeding species. In cooperative breeders, infants are weaned earlier and interact with multiple caregivers right from birth, and therefore must adapt to a richer and more varied social environment. Here, we quantify and analyze gray matter ontogenetic trajectories of the cooperatively breeding (*Homo sapiens*, *Callithrix jacchus*) [1] and independently breeding (*Pan paniscus*, *Macaca mulatta*) primates, and relate them to behavioral and life-history milestones. We find that: (i) cooperatively breeding species share similar relative brain ontogenetic timing; (ii) maximum gray matter volume is achieved after weaning in cooperative breeders but before weaning in independent breeders; (iii) the brain remains plastic until after the birth of the second set of siblings in cooperative breeders, but not in independent breeders. Overall, we find high neuroplasticity during fundamental social milestones and tasks in marmosets and humans, but not in other primates. The rich social environment in which infants of cooperative breeders are raised during a critical period of brain ontogeny appears fundamental for the emergence of the particularly strong socio-cognitive skills that we see in cooperatively breeding species. Our comparative findings have significant implications for our understanding of the evolution of the human adaptive niche, which is strongly defined by social learning.

References: [1] Cerrito, P., Gascon, E., Roberts, A. C., Sawiak, S. J., & Burkart, J. M. (2024). Neurodevelopmental timing and socio-cognitive development in a prosocial cooperatively breeding primate (*Callithrix jacchus*). *Science Advances*, 10(44), eado3486. <https://doi.org/10.1126/sciadv.ado3486> [2] Cerrito, P., & Spear, J. K. (2022). A milk-sharing economy allows placental mammals to overcome their metabolic limits. *Proceedings of the National Academy of Sciences*, 119(10), e2114674119. <https://doi.org/10.1073/pnas.2114674119> [3] Finlay, B. L., & Uchiyama, R. (2020). The timing of brain maturation, early experience, and the human social niche. In *Evolutionary neuroscience* (pp. 815–843). Elsevier. <https://www.sciencedirect.com/science/article/pii/B9780128205846000349> [4] Wilder, L., & Semendeferi, K. (2022). Infant Brain Development and Plasticity from an Evolutionary Perspective. In S. L. Hart & D. F. Bjorklund (Eds.), *Evolutionary Perspectives on Infancy* (pp. 39–57). Springer International Publishing. [https://doi.org/10.1007/978-3-030-76000-7\\_3](https://doi.org/10.1007/978-3-030-76000-7_3) [5] Workman, A. D., Charvet, C. J., Clancy, B., Darlington, R. B., & Finlay, B. L. (2013). Modeling transformations of neurodevelopmental sequences across mammalian species. *Journal of Neuroscience*, 33(17), 7368–7383.

Poster Presentation Number 31, Session 1, Thursday 14:00 - 15:30

## Relationship between mandibular ontogeny and permanent dental eruption in fossil *Homo sapiens* from North Africa

Tannistha Chakraborty<sup>1</sup>, Jean-Jacques Hublin<sup>2,3</sup>, Sarah E. Freidline<sup>1,3</sup>

1 - Department of Anthropology, University of Central Florida, Orlando, FL, USA · 2 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 3 - Chaire Paléanthropologie, CIRB (UMR 7241–U1050), Collège de France, Paris, France

Juvenile mandibular remains attributed to early *Homo sapiens* from the Middle Stone Age (MSA) of North Africa display notable gracility compared to the more robust morphology observed in adult specimens. Fossils recovered from key MSA sites in the Maghreb region – such as Jebel Irhoud, Grotte des Contrebandiers, and Dar-es-Soltane II - exhibit robust cranial and mandibular morphology including a broad braincase, well defined facial superstructure, and megadont dentition [1,2]. At the same time, these specimens show an accumulation of derived features, including a more modern facial morphology, increased cranial capacity, and evidence of a slower growth rate compared to Neanderthals [3,4]. Despite this, how these robust features develop under a slower growth rate remains poorly understood.

This study investigates changes in mandibular corpus shape and cortical bone thickness during the eruption phases of permanent mandibular dentition, from the first molar to the central incisor, to explore the relationship between growth rate and bone modeling. High-resolution micro-computed tomography (CT) scans of juvenile and adult *H. sapiens* mandibles from Jebel Irhoud, Grotte des Contrebandiers, and Dar-es-Soltane II were compared with a sex-balanced sample of 48 known aged recent humans from the New Mexico Decedent Image Database (NMDID) [5]. Geometric morphometric analysis, utilizing landmarks capturing both mandibular corpus shape and dental eruption patterns, was used to visualize mandibular deformation in shape and form space across different stages of dental eruption. Additionally, measurements of cortical bone thickness at the mesio-distal and bucco-lingual cross sections of the permanent first molar, canine, and central incisor were collected to test for correlations with dental eruption phases.

Principal component analyses (PCA) reveal that the fossil *H. sapiens* specimens fall within the range of recent human variation, suggesting comparable growth rates [4]. Procrustes distances, derived from combined dental eruption patterns and mandibular shape configuration, further indicate that fossil *H. sapiens* most closely resemble recent humans of equivalent chronological age. These findings support the use of dental eruption and skeletal development as reliable proxies for reconstructing growth trajectories and reinforce the similarity in growth patterns between fossil and recent humans based on morphological evidence. Additionally, a significant correlation was found between the eruption of permanent dentition and increased cortical bone deposition. Fossil hominins exhibited greater cortical bone thickness relative to recent humans. Collectively, these results suggest that increased cortical bone thickness during the eruption of the permanent dentition may reflect biomechanical demands associated with supporting larger teeth. This study underscores the importance of considering the significant biomechanical demands associated with the eruption of large permanent teeth, alongside other factors such as mastication and genetics, in understanding bone modeling processes during human ontogeny.

We would like to thank Abdelouahed Ben-Ncer, Samir Raoui, Aicha Oujaa, Mohamed Abdeljalil El Hajraoui (Institut National des Sciences du Patrimoine et de l'Archeologie, Rabat); Mohammed Regragui and Mohamed Boutakiout (Mohammed V University, Rabat); and Tanya Smith (Griffith University).

References: [1] Harvati, K., Hublin, J.-J., 2012. Morphological continuity of the face in the Late Middle and Late Pleistocene hominins from Northwestern Africa: A 3D geometric morphometric analysis. *Modern Origins*. 179–188. [2] Hublin, J.-J., Verna, C., Bailey, S., Smith, T., Olejniczak, A., Sbihi-Alaoui, F.Z., Zouak, M., 2012. Dental evidence from the Aterian human populations of Morocco. *Modern Origins*. 189–204. [3] Bergmann, I., Hublin, J.-J., Ben-Ncer, A., Sbihi-Alaoui, F.Z., Gunz, P., Freidline, S.E., 2022. The relevance of late MSA mandibles on the emergence of modern morphology in Northern Africa. *Scientific Reports*. 12. [4] Smith, T.M., Tafforeau, P., Reid, D.J., Grün, R., Eggers, S., Boutakiout, M., Hublin, J.-J., 2007. Earliest evidence of modern human life history in North African early *Homo sapiens*. *Proceedings of the National Academy of Sciences*. 104, 6128–6133. [5] Edgar, HJH; Daneshvari Berry, S; Moes, E; Adolphi, NL; Bridges, P; Nolte, KB, 2020. New Mexico Decedent Image Database. Office of the Medical Investigator, University of New Mexico.

Poster Presentation Number 32, Session 1, Thursday 14:00 - 15:30

## **Depositional history associated with the earliest evidence of hominin fire use in the Karari subregion: Stratigraphy and sedimentology of the Middle Pleistocene, Okote Member, Koobi Fora Formation**

**Molatelo Chokoe<sup>1</sup>, Silindokuhle Mavuso<sup>1,2</sup>**

1 - Department of Geology, Rhodes University · 2 - School of Geosciences, University of the Witwatersrand

The Turkana Basin, Kenya, represents a Plio-Pleistocene palaeoanthropological and archaeological archive. The northeastern expression of the basin, the Koobi Fora Formation, has drawn increasing attention for decades due to consequential finds. One significant find is FxJj20, an archaeological site in the Okote Member associated with stone tool use and the oldest fire evidence associated with hominin behavior. Although the site is well preserved, vertical stratigraphic and sedimentological work has been limited due to sparse outcrop; this shortfall could be remedied by a nearby, recently described, thick outcrop. This study investigated the sedimentology and stratigraphy of the site and its link to the nearby larger outcrop. A detailed sedimentary facies analysis identified nine distinct lithofacies, indicating dynamic interactions between braided river channels and floodplain environments during the Early Pleistocene. Stratigraphic correlation between Outcrop 1 and the FxJj20 Site Complex was achieved by the occurrence of the lower Okote Tuff (1.64 Ma) the upper Morutut Tuff (1.6 Ma), suggesting a period of contemporaneous deposition. The transition from high-energy braided river systems to more stable floodplain settings reveals the influence of hominins in habitat selection; these landscapes would have shaped hominin resource availability. The braided river likely offered diverse, short-term resources, while the floodplain at FxJj20 provided stable access to water, food, and raw materials, supporting the extended occupation. These findings contribute to a deeper understanding of how dynamic environmental conditions influenced early hominin adaptation in the Turkana Basin. By linking sedimentary processes to archaeological context, this research highlights the complex relationship between landscape evolution and human behavioural responses during the Early Pleistocene.

Poster Presentation Number 33, Session 1, Thursday 14:00 - 15:30

## What can handaxe shape contribute to discussions of hominin demography in Africa in the late Early and Middle Pleistocene?

James Clark<sup>1,2</sup>

1 - Corpus Christi College, University of Cambridge · 2 - McDonald Institute for Archaeological Research, University of Cambridge

The formation of the *Homo sapiens* lineage and the resulting demographic structure of hominin populations in Africa is a topic of extensive attention and recent debate. This debate has been hampered by the lack of available and well-dated hominin fossils across the continent in the late Early and Middle Pleistocene, as well as by the complete absence of ancient genomes from individuals that predate the Holocene. In contrast, there is an abundance of archaeological material recovered from this period which combined can make powerful inferences about population structure and demography, despite each artefact having less resolution than an individual fossil or ancient genome. This has been done successfully with artefacts from the Middle Stone Age, but this only allows exploration of dynamics in the last 300 thousand years (ka). A diversity of studies of handaxe form through time and space have shown that handaxe shape preserves information about the history of populations through the formation of local cultural norms, both within and between large subcontinental regions, and thus handaxe shape has major potential to fill this research gap. This may shed light on population history within different regions of Africa, and therefore on the demography of our species in deep time.

Here, I present an analysis of 2D outline shape from almost 1000 handaxe specimens from the Early and Middle Pleistocene of Northern, Eastern, and Southern Africa, as well as neighbouring regions to which the continent cyclically forms biogeographic connections. The results highlight a complex series of patterns in which Eastern Africa sees a homogenisation of handaxe shape in the late Early Pleistocene, followed by morphological continuity through time. Northern Africa, in contrast, appears to have a series of divergent assemblages throughout the Middle Pleistocene, perhaps related to different sources of dispersal. Southern Africa shows similarity between assemblages from 1000 to 300 ka, but ultimately sees a late shift towards variation more similar to Eastern Africa. The implications for hominin biogeography across the continent are discussed.

I wish to thank my collaborators who have worked with me on prior publication of some of the data used in this analysis. I also extend my gratitude to a number of members of the Ng'ipalajem Research Project, namely Marta Mirazón Lahr, Robert Foley, Sarah Paris, Avantika Binani, Otto Geissler, and Thomas Van Parys, for their support and comments on an earlier version of this poster.

Poster Presentation Number 34, Session 1, Thursday 14:00 - 15:30

## The bony labyrinth of *Homo naledi*

Zachary Cofran<sup>1</sup>, Amélie Beaudet<sup>2</sup>, Gideon Chinamatira<sup>3</sup>, John Hawks<sup>4</sup>

1 - Vassar College · 2 - PALEVOPRIM CNRS – Université de Poitiers · 3 - University of the Witwatersrand · 4 - University of Wisconsin-Madison

A wealth of skeletal remains from Rising Star Cave, South Africa is exclusively attributed to *Homo naledi* who lived alongside modern human ancestors around 300,000 years ago. This assemblage presents an unexpected mix of ancestral and derived features, raising questions about the adaptations and phylogenetic position of *Homo naledi*. To address these issues, we present new evidence from the bony labyrinth, the cavity within the petrosal bone housing the membranous organs of hearing (within the spiral-shaped cochlea) and balance (within three semicircular canals).

We virtually extracted the bony labyrinths from microCT scans of five *Homo naledi* petrosal bones, representing four individuals, by manual segmentation in Avizo software. We analyzed the size and shape of the labyrinth using an established protocol of 3D landmark-based geometric morphometrics, and compared these data to samples of modern humans (N=10) and chimpanzees (N=10), and South African *Australopithecus* (N=11), *Paranthropus* (N=2), and Early *Homo* (N=2) [1].

*Homo naledi* and both extant and Early *Homo* have disproportionately enlarged anterior and posterior semicircular canals, whereas all three semicircular canals are of similar size in chimpanzees and australopiths. *Homo naledi* is distinct from all taxa in presenting a more vertically-inclined lateral semicircular canal. The enlarged vertical canals of extinct and extant *Homo* indicate that this sensory adaptation to bipedal locomotion arose early in the genus. It is unclear, however, whether the subtle difference in the lateral canal of *Homo naledi* had functional consequences.

In terms of cochlear shape, principal components analysis distinguishes a longer and more coiled shape characterizing chimpanzees, humans, and *Australopithecus*, from the other taxa including *Homo naledi* with fewer turns along a shorter cochlea. Across all taxa, the first principal component accounts for 80% of the variance in cochlear shape and is strongly correlated ( $r=0.73$ ) with the length of the cochlea relative to overall labyrinth size. Thus, while it is possible that cochlear shape variation in this sample reflects different auditory adaptations, this variation could also result from spatial constraints due to cochlear length.

In the present sample, the bony labyrinth of *Homo naledi* is most similar to Early Pleistocene *Homo*. Yet there is also interesting intraspecific variability in the Rising Star sample. Two labyrinths are from petrosal bones that were previously identified as right and left antimeres of the same individual, and their pairwise Procrustes distance (measuring shape difference) is by far the lowest among all possible pairs in the sample. This result suggests that labyrinth shape similarity could be used to associate fragments in commingled fossil assemblages. The largest *Homo naledi* labyrinth in our sample presents an unusually thin and twisted anterior semicircular canal, which may be due to a semicircular canal dehiscence — the earliest example of such a condition in the fossil record.

We thank B. Zipfel and S. Jirah (University of the Witwatersrand), L. Kgasi, H. Fourie, S. Potze, and M. Tawane (Ditsong National Museum of Natural History), G. Krüger and E. L'Abbe (University of Pretoria), and E. Gillisen and W. Wendelen (Royal Museum for Central Africa) for granting access to fossils and comparative material. We are grateful for their hospitality and assistance with the collections. AB thanks the CNRS (CPJ - Hominines) for funding.

References: [1] Beaudet, A., Clarke, R.J., Bruxelles, L., Carlson, K.J., Crompton, R., de Beer, F., Dhaene, J., Heaton, J.L., Jakata, K., Jashashvili, T., Kuman, K., McClymont, J., Pickering, T.R., Stratford, D., 2019. The bony labyrinth of StW 573 ("Little Foot"): Implications for early hominin evolution and paleobiology. *Journal of Human Evolution*. 127, 67–80.

Poster Presentation Number 35, Session 1, Thursday 14:00 - 15:30

## Dental morphology and biological affinities of Ibero-Maurusian populations from Taforalt and Afalou

Thomas Colard<sup>1,2</sup>, Isabelle Crevecoeur<sup>1</sup>, Nicolas Martin<sup>1</sup>, Tony Chevalier<sup>3,4</sup>

1 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, F-33600 Pessac, France · 2 - Department of Oral and Maxillofacial Radiology, Univ. Lille, Lille University Hospital, Lille, France · 3 - Histoire Naturelle des Humanités Préhistoriques (HNHP, UMR 7194), PaleoFED, MNHN/CNRS/UPVD, Musée de l'Homme, Paris, France · 4 - Centre Européen de Recherches en Préhistoire de Tautavel, Tautavel, France

The Ibero-Maurusian was a prehistoric culture of the Maghreb that emerged around 22,000 years and lasted until approximately 11,000 years before present (YBP). It was named based on the initially perceived similarities between its microlithic tools and those found at the same time in southern Spain. Ibero-Maurusian populations were primarily hunter-gatherers, using microlithic tools characteristic of this culture. Among the key archaeological sites are Taforalt in Morocco and Afalou in Algeria, both of which have yielded evidence of elaborate funerary practices [1].

The Grotte des Pigeons at Taforalt, located in the Bni Snassen Mountains of northeastern Morocco, is one of the most significant archaeological sites in North Africa. Occupied between approximately 120,000 and 12,000 YBP, it is associated with both earlier Aterian levels and Ibero-Maurusian cultural phases. Excavations of the latter archaeological layers have revealed human burials dating from around 15,000 to 10,000 YBP. Recent genetic analyses from these remains have highlighted ancient connections with sub-Saharan Africa and the Near East [2]. The Afalou Bou Rhummel site, located in the Babor Mountains of Algeria, is a major prehistoric rock shelter, initially excavated by Camille Arambourg between 1928 and 1930. It produced approximately fifty human skeletons dated to between 15,000 and 11,000 YBP.

While numerous studies have focused on the funerary and cultural practices of these populations, relatively few have studied in details their morphological features, or their biological affinities with other North African populations during the Pleistocene–Holocene transition. This study aims to examine the dental morphology of individuals from Taforalt and Afalou, and to compare them with North African populations from the Late Pleistocene to Early Holocene Nile Valley (Jebel Sahaba, El Barga, Sphinx, Letti), the Mid–Late Holocene Horn of Africa (Ali Daba, Hara Ide 2), the Late Holocene Western Desert (Abu Tabari), and with both modern and sub-modern populations (from medieval to present-day humans).

The enamel–dentin junction (EDJ) is a highly reliable proxy for morphological and biological affinity analyses [3], especially in mandibular molars, which preserve strong biological signals. A landmark-based 3D geometric morphometric analysis was applied to the EDJ of first permanent mandibular molars (LM1) and second deciduous mandibular molars (Ldm2) from Epipaleolithic individuals at Taforalt and Afalou. Principal Component Analyses (PCA), between-group PCA (bgPCA), and typicality probabilities were performed. Additionally, crown dimensions, non-metric traits at the EDJ, and variations in the shape of the dentine horns were analyzed.

Results of the geometric morphometric analyses indicate a clear biological affinity between the Ibero-Maurusian populations of Afalou and Taforalt. They also appear as a distinct group from modern European humans, although some overlap occurs within the morphospace. Furthermore, they share biological affinities with North African populations, supporting genetic studies that indicate gene flow between the southern and northern coasts of the Mediterranean [4].

This research benefited from the scientific framework of the University of Bordeaux's IdEx "Investments for the Future" program/GPR "Human Past". The authors want to thank the Institut de Paléontologie Humaine (Paris), the IRP ABASC, the ANR grant BIGDRY, the NeoNile project and the Duckworth Laboratory (Univ. Cambridge) Bayle, Univ Perpignan (UPVD).

).

References: [1] Humphrey, L., Bello, S.M., Turner, E., Bouzouggar, A., Barton, N., 2012. Iberomaurusian funerary behaviour: Evidence from Grotte des Pigeons, Taforalt, Morocco. *Journal of Human Evolution*. 62, 261–273. [2] van de Loosdrecht, M., Bouzouggar, A., Humphrey, L., Posth, C., Barton, N., Aximu-Petri, A., Nickel, B., Nagel, S., Talbi, E.H., El Hajraoui, M.A., Amzazi, S., Hublin, J.-J., Pääbo, S., Schiffels, S., Meyer, M., Haak, W., Jeong, C., Krause, J., 2018. Pleistocene North African genomes link Near Eastern and sub-Saharan African human populations. *Science*. 360, 548–552. [3] Martin, N., Thibault, A., Varadinová, L., Usai, D., Ambrose, S.H., Antoine, D., Brukner Havelková, P., Honegger, M., Irish, J.D., Jesse, F., Maréchal, L., Osypinska, M., Osypinski, P., Santos, F., Vandereesse, N., Varadin, L., Whiting, R.J., Zanoli, C., Velemínský, P., Crevecoeur, I., 2025. Enamel–dentine junction morphology reveals population replacement and mobility in the late prehistoric Middle Nile Valley. *Proceedings of the National Academy of Sciences*. 122. [4] Kefi, R., Hechmi, M., Naouali, C., Jmel, H., Hsouna, S., Bouzaid, E., Abdelhak, S., Beraud-Colomb, E., Stevanovitch, A., 2016. On the origin of Iberomaurusians: new data based on ancient mitochondrial DNA and phylogenetic analysis of Afalou and Taforalt populations. *Mitochondrial DNA Part A*. 29, 147–157.

Poster Presentation Number 36, Session 1, Thursday 14:00 - 15:30

## A test of the archaic *Homo* introgression hypothesis for the Chiari malformation type I

Mark Collard<sup>1</sup>, Kimberly Plomp<sup>2</sup>, Daniel Lewis<sup>3,4</sup>, Laura Buck<sup>5</sup>, Shafqat Bukhari<sup>4</sup>, Todd Rae<sup>6</sup>, Kanna Gnanalingham<sup>3,4</sup>

1 - Laboratory of Human Evolutionary Studies, Department of Archaeology, Simon Fraser University, Burnaby, British Columbia, Canada · 2 - School of Archaeology, University of the Philippines Diliman, Quezon City, Philippines · 3 - School of Biological Sciences, University of Manchester, Manchester, UK · 4 - Department of Neurosurgery, Manchester Centre for Clinical Neurosciences, Salford Royal NHS foundation trust, Manchester Academic Health Science Centre, Manchester, UK · 5 - Research Centre for Evolutionary Anthropology and Palaeoecology, School of Biological and Environmental Sciences, Liverpool John Moores University, Liverpool, UK · 6 - School of Life Sciences, University of Sussex, Sussex House, Falmer, Brighton, UK

The Chiari malformation type I (CM-I) is a developmental, neurological condition in which the cerebellum protrudes through the foramen magnum into the spinal canal. The condition is usually said to affect 1 in 1000 people, but recent studies suggest that the prevalence may be markedly higher. Symptoms range from occipital-region headaches and neck pain to the development of hydrocephalus, syringomyelia, and brainstem compression.

The proximate cause of CM-I is widely accepted that is an unusually small occipital bone, but the condition's ultimate cause remains unclear. A few years ago, Fernandes et al. [1] linked it to the phenomenon of introgression. They argued that individuals develop CM-I because some of their cranial development-coding genes derive from three extinct species of *Homo* that have smaller basicrania than modern humans—*Homo erectus*, *Homo heidelbergensis*, and *Homo neanderthalensis*. The genes in question, entered the modern human gene pool, Fernandes et al. suggested, as a result of interbreeding. Here, we report a study designed to test this 'Archaic *Homo* Introgression Hypothesis'.

The study employed 3D cranial data and Geometric Morphometrics in two sets of analyses. The first set of analyses tested the hypothesis' key assumption, which is that CM-I is associated with significant differences in cranial shape in living humans and the differences should be particularly apparent in the basicranium. This test involved analysis of landmarks recorded on digital models derived from CT scans of 103 living adult humans, 46 of whom had been diagnosed with CM-I and 57 of whom did not have CM-I. All living participants provided informed consent. In the second set of analyses, we compared crania of living humans with and without CM-I to fossil crania assigned to *H. erectus* (KNM-ER 3733, KNM-ER 3883), *H. heidelbergensis* (Kabwe 1), *H. neanderthalensis* (Amud 1, La Chapelle-aux-Saints 1, La Ferrassie 1), and *H. sapiens* (Singa 1, Skhul IV). The goal of this set of analyses was to test the main prediction of the hypothesis, which is that crania of living humans with CM-I should be more similar to crania of *H. erectus*, *H. heidelbergensis*, and *H. neanderthalensis* than are crania of living humans without CM-I, especially in the basicranium.

The results of the first set of analyses were consistent with the hypothesis' key assumption. We found significant differences between the crania of people with and without CM-I. Importantly, several of the differences concern the basicranium. The analyses indicated that, compared to individuals without CM-I, individuals with CM-I tend to have reduced cranial vault height; reduced occipital height and width; a more inferiorly located asterion and inion; a more posteriorly located pterion; and a more anteriorly located and smaller foramen magnum. In contrast, the second set of analyses did not support the hypothesis. We found that the crania of living humans with CM-I are closer in shape to those of *H. neanderthalensis* than are the crania of living humans without CM-I, as predicted. However, the situation was different with respect to *H. erectus* and *H. heidelbergensis*. Both were found to be closer in shape to living humans without CM-I than to living humans with CM-I. This is inconsistent with the main prediction of the hypothesis.

The simplest explanation for our results is that the hypothesis is too broad with respect to the species from which the relevant cranial development-coding genes derive. Rather than the genes being traceable to *H. erectus*, *H. heidelbergensis*, and *H. neanderthalensis*, our results are consistent with them being traceable just to *H. neanderthalensis*. We call this revised version of the hypothesis the 'Neanderthal Introgression Hypothesis'.

This project was supported by the European Union's Marie Skłodowska-Curie Actions program (Horizon 2020-748200), the Canada Research Chairs Program (231256), the Canada Foundation for Innovation (36801), and the British Columbia Knowledge Development Fund (962-805808).

References: [1] Fernandes, Y.B., Ramina, R., Campos-Herrera, C.R., Borges, G., 2013. Evolutionary hypothesis for Chiari type I malformation. *Medical Hypotheses*. 81, 715–719.

Poster Presentation Number 37, Session 1, Thursday 14:00 - 15:30

## The nexus of technology and cognition: archaeology's four major signposts

Frederick L. Coolidge<sup>1</sup>

1 - University of Colorado, Colorado Springs

We hypothesize at least four major archaeological signposts in hominin technical cognition: (1) the advent of stone knapping, ca. 3.3 million years ago; (2) the development of handaxes, ca. 1.8 million years ago; (3) the invention of hafting, ca. 500,000-300,000 years ago; and (4) the invention of the bow-and-arrow, ca. 70,000 years ago. In this paper, we use Osiurak and Reynaud's [1] theory of technical cognition (a.k.a. technition) and Pain's [2] method of Cognitive Transition Inference (CTI) to identify these four distinct technical innovations evident in the Palaeolithic archaeological record. We use the term signposts instead of Pain's transitions because the former term is vaguer and pays respect to the temporal uncertainty of most cognitive developments in hominin evolution. The two components of Osiurak and Reynaud's term technition are mechanical knowledge and technical reasoning. Their model emphasizes non-semantic knowledge and organizational principles that allow the assessment of the products of pre-linguistic hominins and is also more aligned with ethnographic accounts of tool use and craft production. Pain's CTIs focus on well-documented episodes in the narrative of human evolution when seemingly significant changes occurred. This approach has the advantage of beginning with well-known and accepted episodes in human evolution, thus bringing the archaeological record itself into prominence and a more longitudinal discussion of cognitive evolution, while sidestepping more controversial accounts of a single hominin species. We use a modified version of CTIs in which we identify several important developments and interpret them using a single theory of technical cognition. We conclude that (a) the initial development of stone-tool technology relied on anthropoid primate levels of technical cognition. It was an extension of natural ergonomic components of hominin body schemas and was effectively an inchoate form of embodied/extended cognition; (b) technition during the handaxe age was neither ape-like nor human-like, but had several features that are unknown for modern non-human primate technologies: curation; coordination of spatial thinking and shape recognition; overdetermination of form; technology organized as expert performance; and perhaps a tool concept. Intentional developments of new technologies using abstract understandings of causality appear to have been absent from handaxe culture until very late in its tenure; (c) The development of hafting could not have occurred via the gradual accrual of small changes that previously characterized hominin technology. These complex procedures required a sophisticated understanding of stone knapping in the form of flexible mechanical principles. It is even likely that they were able to imagine outcomes (e.g., a hafted spear) using constructive episodic memory; and (d) the fourth signpost, the invention of the bow-and-arrow, marks the emergence of fully modern technical cognition [3]. Its components required a large number of technical routines and sub-routines, including different raw materials acquired from different locations and were likely a multi-day, discontinuous procedure task, highly suggestive of executive functions and working memory [4,5]. The later use of poisonous tips must have been based on a "folk chemistry" that included poisonous substances learned experientially and laboriously. In a CTI inference, these understandings of stored energy and toxicity required the ability to analyze technologies into abstract components and apply these components in novel ways. These are important components of modern technition and such abstract problem solving was not required for antecedent technologies. It was the abstracting power of mechanical principles that enabled the bow and arrow. It is this technical cognition that drives human technology and technical change even in the modern world.

Thomas Wynn contributed substantially to this paper.

References: [1] Osiurak, F., Reynaud, E., 2020. The elephant in the China shop: When technical reasoning meets cumulative technological culture. *Behavioral and Brain Sciences*. 43, e183. [2] Pain, R., 2021. What can the lithic record tell us about the evolution of hominin cognition? *Topoi*. 40, 245-259. [3] Coolidge, F.L., Haidle, M.N., Lombard, M., Wynn, T., 2016. Bridging theory and bow hunting: Human cognitive evolution and archaeology. *Antiquity*. 90, 219-228. [4] Coolidge, F.L., Wynn, T., 2001. Executive functions of the frontal lobes and the evolutionary ascendancy of *Homo sapiens*. *Cambridge Archaeological Journal*. 11, 255-260. [5] Coolidge, F.L., Wynn, T., 2005. Working memory, its executive functions, and the emergence of modern thinking. *Cambridge Archaeological Journal*. 15, 5-26.

References: [1] Trinkaus, E., Ruff, C.B., 2012. Femoral and Tibial Diaphyseal Cross-Sectional Geometry in Pleistocene *Homo*. *PaleoAnthropology* 2012, 13–62. [2] Rodríguez, L., Carretero, J.M., García-González, R., Arsuaga, J.L., 2018. Cross-sectional properties of the lower limb long bones in the Middle Pleistocene Sima de los Huesos sample (Sierra de Atapuerca, Spain). *Journal of Human Evolution*. 117, 1–12. [3] Chapman, T., Sholukh, V., Semal, P., Louryan, S., Van Sint Jan, S., 2018. Further consideration of the curvature of the Neandertal femur. *American Journal of Physical Anthropology* 165, 94–107. [4] Cowgill, L.W., 2010. The ontogeny of Holocene and Late Pleistocene human postcranial strength. *American Journal of Physical Anthropology* 141, 16–37.

Poster Presentation Number 39, Session 1, Thursday 14:00 - 15:30

## Craniofacial gracilisation during human evolution and its relationship to masticatory loading

Kira Crabtree<sup>1</sup>, Laura C. Fitton<sup>1,2</sup>

1 - Department of Archaeology, University of York, York, UK · 2 - Centre for Anatomical and Human Sciences, Hull York Medical School, University of York, York, UK

Modern *Homo sapiens* exhibit a gracile craniofacial skeleton compared to earlier members of the genus. This is evident in the reduction of the size and robusticity of the zygomatic region, a key area involved in facial structure and mastication. This suite of morphological changes is argued to reflect shifts in masticatory function during the evolution of the genus *Homo*, chiefly a relaxation of selective pressures upon the ability of the masticatory apparatus to produce and resist the high bite forces. Many assume this relaxation is the product of the advancement of extra oral food processing behaviours within the genus, reducing the mechanical challenge posed by dietary items. This study uses Finite Element Analysis to explore whether the gracilisation of the zygomatic region within the genus *Homo* is linked to advancements in extra-oral food preparation techniques, by investigating the relationship between its morphological form and function during different feeding behaviours. Less investigated in paleoanthropological literature, we specifically address the role that wide-gape biting may have had upon craniofacial form in the genus *Homo*. We test whether incorporating early *Homo*-like zygomatic morphology into an otherwise unmodified *H. sapiens* model results in higher predictions of bite force and lower craniofacial strain magnitudes under a range of masticatory loading conditions including bites at different jaw gapes.

A voxel-based FE model of an adult female *H. sapiens* individual was constructed from a cadaveric CT scan following validated protocols [1-3]. To isolate the functional contribution of zygomatic form to masticatory performance, the zygomatic region of the *H. sapiens* specimen was digitally modified using morphometric warping to resemble that of KNM-ER 3733 (*H. ergaster*) to produce a modified FE model, following established protocols [4]. Four bite scenarios were simulated for each model: an incisor (I<sup>1</sup>) and molar (LM<sup>1</sup>) bite at minimum (0mm) and maximal (40mm) gapes. Muscle force vectors simulating the action of the jaw-elevator musculature were applied to each model, with their orientation determined based upon mandibular position during bites at either gape. The models were constrained at the I<sup>1</sup>s or LM<sup>1</sup>s, as well as at both temporomandibular joints, with the position of these constraints determined based on position of the mandibular condyle in relation to the articular eminences during bites at either gape. Muscle force magnitudes were identical across all loading scenarios [5]. Von Mises strain and bite force magnitudes were calculated for each simulation.

The results revealed that bite force differences between models were minimal. During bites at minimum gape, the modified model did not uniformly exhibit lower strain relative to the unmodified model, with strain decreasing in some areas local to the zygomatic region but increasing in others. However, during bites at maximal gape, the modified model showed reduced strain in many areas local to the zygomatic region.

These findings indicate that the robust, projecting zygoma of *H. ergaster* appears better optimised for resisting strain during wide gape feeding, therefore gracilisation of this region within *H. sapiens* may reflect a reduced need for wide-gape biting, consistent with a dietary shift towards smaller, more processed foods; both suggest that food object size may have selectively influenced hominin facial form. This study demonstrates simulating different jaw positions meaningfully alter strain and bite force predictions of FE models, reinforcing the importance of loading models under a full range of realistic masticatory scenarios. Overall, this research demonstrates that jaw gape may be an important functional variable to consider in interpreting hominin craniofacial evolution and demonstrates the value of combining morphometric warping with finite-element analysis to reveal the functional consequences of evolutionary change.

We would like to thank the New Mexico Decedent imaging database for providing access to the CT scan of the *H. sapiens* individual used within this research, in addition to the Department of Earth Sciences of the National Museum of Kenya for providing access to the CT scan of KNM-ER 3733.

References: [1] Fagan, M.J., Curtis, N., Dobson, C.A., Karunanayake, J.H., Kupeczik, K., Moazen, M., Page, L., Phillips, R., O'Higgins, P., 2007. Voxel-based finite element analysis – Working directly with microCT scan data. *Journal of Morphology* 268, 1071. [2] Toro-Ibacache, V., Fitton, L.C., Fagan, M.J., O'Higgins, P., 2015. Validity and sensitivity of a human cranial finite element model: implications for comparative studies of biting performance. *Journal of Anatomy*. 228, 70–84. [3] Fitton, L.C., PröA, M., Rowland, C., Toro-Ibacache, V., O'Higgins, P., 2014. The impact of simplifications on the performance of a finite element model of a *Macaca fascicularis* cranium. *The Anatomical Record*. 298, 107–121. [4] O'Higgins, P., Cobb, S.N., Fitton, L.C., Gröning, F., Phillips, R., Liu, J., Fagan, M.J., 2010. Combining geometric morphometrics and functional simulation: an emerging toolkit for virtual functional analyses. *Journal of Anatomy*. 218, 3–15. [5] Toro-Ibacache, V., O'Higgins, P., 2016. The effect of varying jaw-elevator muscle forces on a finite element model of a human cranium. *The Anatomical Record*. 299, 828–839.

Poster Presentation Number 40, Session 1, Thursday 14:00 - 15:30

## The Iberian case: reconstructing the niche of West Europe's first hominins (ca. 1.1 Ma)

Carolina Cucart-Mora<sup>1</sup>, Kamilla Lomborg<sup>2</sup>, Jan-Olaf Reschke<sup>1</sup>, Matt Grove<sup>3</sup>, Christine Hertler<sup>4</sup>, Marie-Hélène Moncel<sup>1</sup>

1 - CNRS UMR 7194 HNHP, National Museum of Natural History, Institut de Paleontologie Humaine, Paris, France · 2 CNRS UMR 5602 GEODE Géographie de l'Environnement, Maison de la Recherche, Université Toulouse 2 Jean Jaurès, Toulouse, France · 3 - Department of Archaeology, Classics and Egyptology, University of Liverpool, Liverpool, UK · 4 - ROCEEH Research Center, Senckenberg Research Institute, Frankfurt am Main, Germany

The oldest evidence of hominin presence in Western Europe (1.4-1.2 Ma) is documented in the Iberian Peninsula and Italy. In this study, we focus on the Iberian Peninsula, a region with an exceptional Early Pleistocene record, as it provides most of the European paleoanthropological record for the period and the most complete stratigraphic sequences, particularly at the Sierra de Atapuerca sites. There is a consensus that early hominids, during the process of dispersion into Western Europe, were susceptible to climatic fluctuations. Paleoenvironmental reconstructions suggest that these occupations took place during warm and wet interglacial or mild glacial. A recent study applying niche modelling suggests that hominin habitat suitability dropped substantially during the peak of the MIS 34 terminal stadial event [1]. The worsening of climatic conditions would have led to the extinction of hominin populations. In this regard, the remains from Sima del Elefante (1.4 -1.1 Ma) (Atapuerca, Spain) ascribed to *Homo aff. erectus* [2] in contrast to the *Homo antecessor* [3] from Gran Dolina (ca. 900 ka) (Atapuerca, Spain) suggest a population turnover took place around the same time that the documented drop in habitat suitability.

Therefore, it is vital to understand the climatic context in which these early populations developed, as well as how this context may have affected them. To this end, within the modelling package of the LATEUROPE ERC project, we focus on the use of climate reconstructions to project changes in the niche of hominid populations in the Iberian Peninsula. Specifically, we use an up-to-date dataset on the presence of hominins in Africa, Asia, and Europe, and apply Mahalanobis distance to reconstruct the changes in hominins' habitat suitability during the Early Pleistocene. The same dataset and method are used with two different climatic reconstructions, Paleo-PGM [4] and Oscillayers [5], which are characterized by their different spatial and temporal resolutions. Our preliminary results allow us to: i) evaluate how habitat suitability evolved during these critical times and what this would mean for hominin populations and the process of population of Western Europe, ii) evaluate the appropriateness of the available climatic reconstructions to answer questions about regional and continental population dynamics.

References: [1] Margari, V., Hodell, D.A., Parfitt, S.A., Ashton, N.M., Grimalt, J.O., Kim, H., Yun, K.-S., Gibbard, P.L., Stringer, C.B., Timmermann, A., Tzedakis, P.C., 2023. Extreme glacial cooling likely led to hominin depopulation of Europe in the Early Pleistocene. *Science*. 381, 693–699. [2] Huguet, R., Rodríguez-Álvarez, X.P., Martínón-Torres, M., Vallverdú, J., López-García, J.M., Lozano, M., Terradillos-Bernal, M., Expósito, I., Ollé, A., Santos, E., Saladié, P., de Lombera-Hermida, A., Moreno-Ribas, E., Martín-Francés, L., Allué, E., Núñez-Lahuerta, C., van der Made, J., Galán, J., Blain, H.-A., Cáceres, I., Rodríguez-Hidalgo, A., Bargalló, A., Mosquera, M., Parés, J.M., Marín, J., Pineda, A., Lordkipanidze, D., Margveslashvili, A., Arsuaga, J.L., Carbonell, E., Bermúdez de Castro, J.M., 2025. The earliest human face of Western Europe. *Nature*. 640, 707–713. [3] Bermúdez de Castro, J.M., Arsuaga, J.L., Carbonell, E., Rosas, A., Martínez, I., Mosquera, M., 1997. A Hominid from the Lower Pleistocene of Atapuerca, Spain: Possible Ancestor to Neandertals and Modern Humans. *Science*. 276, 1392–1395. [4] Barreto, E., Holden, P.B., Edwards, N.R., Rangel, T.F., 2023. PALEO-PGEM-Series: A spatial time series of the global climate over the last 5 million years (Plio-Pleistocene). *Global Ecology and Biogeography*. 32, 1034–1045. [5] Gamisch, A., 2019. Oscillayers: A dataset for the study of climatic oscillations over Plio-Pleistocene time-scales at high spatial-temporal resolution. *Global Ecology and Biogeography*. 28, 1552–1560.

Poster Presentation Number 41, Session 1, Thursday 14:00 - 15:30

## TOOTHROW: a multiple tooth geometric morphometric protocol

Thomas W. Davies<sup>1</sup>, Matthew M. Skinner<sup>2</sup>, Philipp Mitteröcker<sup>1,3</sup>

1 - Department of Evolutionary Biology, University of Vienna, Vienna, Austria · 2 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 3 - Konrad Lorenz Institute for Evolution and Cognition Research, Klosterneuburg, Austria

Our interpretations of the hominin fossil record depend on reliable taxonomic identification of fossils and a robust understanding of their phylogenetic relationships. Teeth provide an important source of evidence; due to their preferential preservation in the fossil record they are greatly overrepresented compared to other skeletal regions [1]. They also contain a wealth of morphological information, and, unlike bones, they are not remodelled throughout an individual's lifetime. A well-established method of quantifying tooth morphology involves 3D geometric morphometric (GM) analysis of the enamel-dentine junction [2,3]. Typically, this method requires each tooth position to be analysed individually, often resulting in a large number of analyses which cannot reveal potentially taxonomically relevant patterns of co-variation between teeth along the tooth row. Here we develop a GM protocol to address this issue by combining several tooth positions in a single analysis, comparing with the single-tooth method.

Our sample consists of micro-CT scans of gorillas, chimpanzees, modern humans and Neanderthals, each preserving the entire mandibular postcanine tooth row (P<sub>3</sub>-M<sub>3</sub>). We collected landmarks on the cementum-enamel junction (CEJ) for each tooth, which typically provides poorer taxonomic distinction compared to analyses that include the EDJ marginal ridges. We conducted separate GM analyses of each tooth position, followed by a combined analysis in which all tooth positions are included. We then calculated classification accuracies for each analysis, based on linear discriminant analysis using the first five principal components and leave-one-out cross-validation.

We find that the classification accuracies based on the shape of individual tooth positions range from 68% to 89%, with the M<sub>1</sub> providing the highest classification accuracy, and M<sub>3</sub> providing the worst. By contrast, when all tooth positions are combined, specimens are correctly classified 95% of the time. This combined tooth position analysis correctly classifies all Gorillas, Chimpanzees and modern humans. In form space, classification accuracies are improved for all analyses, with particular improvement in distinguishing modern humans and Neanderthals. Analyses of individual teeth classify specimens correctly between 81% and 97% of the time, while in the combined tooth position analysis, all specimens are correctly classified.

These results demonstrate a distinct improvement in discriminatory power when including multiple teeth. As fossil specimens frequently preserve only partial tooth rows, further developments will focus on providing statistically based reconstructions of missing teeth to allow for the inclusion of incomplete specimens.

This work is funded by the European Union under the Horizon Europe research and innovation program – Marie Skłodowska-Curie Actions Postdoctoral Fellowship #101150845. For access to specimens and micro-CT scans, we would like to thank the TAI chimpanzee project, Museum für Naturkunde Berlin, Institut für Anatomie der Universität Leipzig, Croatian Natural History Museum, Museo Archeologico del Finale, National Prehistory Museum Balzi Rossi, Institute of Archeology Brno, Museum für Vor- und Frühgeschichte Berlin, Musée d'Art et d'Archéologie du Périgord, ASBL Archéologie Andennaise and Musée d'Archéologie nationale de Saint-Germain-en-Laye.

References: [1] McRae, R.T., Wood, B., 2025. Hominin fossil inventory: Quantification and comparison of discrete regional and element representation among early African fossil hominins prior to the emergence of *Homo erectus*. *Journal of Human Evolution*. 198, 103615. [2] Skinner, M.M., Gunz, P., Wood, B.A., Boesch, C., Hublin, J., 2009. Discrimination of extant *Pan* species and subspecies using the enamel-dentine junction morphology of lower molars. *American Journal of Physical Anthropology*. 140, 234–243. [3] Zanolli, C., Davies, T.W., Joannes-Boyau, R., Beaudet, A., Bruxelles, L., de Beer, F., Hoffman, J., Hublin, J.-J., Jakata, K., Kgasi, L., Kullmer, O., Macchiarelli, R., Pan, L., Schrenk, F., Santos, F., Stratford, D., Tawane, M., Thackeray, F., Xing, S., Zipfel, B., Skinner, M.M., 2022. Dental data challenge the ubiquitous presence of *Homo* in the Cradle of Humankind. *Proceedings of the National Academy of Sciences*. 119.

Podium Presentation, Session 3, Thursday 16:00 – 17:40

## Reconstructing the evolution of cerebral reorganisation in the hominin fossil record

Edwin de Jager<sup>1</sup>, Caroline Fonta<sup>2</sup>, Muriel Mescam<sup>2</sup>, Laurent Risser<sup>3</sup>, Céline Amiez<sup>4</sup>, Kristian Carlson<sup>5,6</sup>, Heather Garvin<sup>7,8</sup>, Lazarus Kgasi<sup>9,10</sup>, Dominic Stratford<sup>11,12</sup>, Bernhard Zipfel<sup>6</sup>, Amélie Beaudet<sup>1,11,13</sup>

1 - Department of Archaeology, University of Cambridge, Cambridge, United Kingdom · 2 - Université de Toulouse, CNRS, CerCo, Toulouse, France · 3 - Institute de Mathématiques de Toulouse, Université de Toulouse, UPS, Toulouse, France · 4 - Université Lyon 1, Inserm, Stem Cell and Brain Research Institute, INSERM U1208, Bron, France · 5 - Division of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, Los Angeles, USA · 6 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa · 7 - Department of Anatomy, Des Moines University, Des Moines, USA · 8 - Centre for the Exploration of the Deep Human Journey, University of Witwatersrand, Johannesburg, South Africa · 9 - Ditsong National Museum of Natural History, Pretoria, South Africa · 10 - Palaeo-Research Institute, University of Johannesburg, Johannesburg, South Africa · 11 - School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa · 12 - Department of Anthropology, Stony Brook University, Stony Brook, New York, USA · 13 - Laboratoire de Paléontologie, Évolution, Paléoécosystèmes et Paléoprimatologie (PALEVOPRIM), UMR 7262 CNRS & University of Poitiers, Poitiers, France

A major challenge in palaeoneurology is tracing the evolutionary emergence of derived cortical features in hominins. In the absence of fossilised brain tissue, researchers rely on cranial endocasts, casts of the braincase, to study cerebral organisation. While early interpretations were limited by subjectivity and taxonomic assumptions [1], recent advances in digital imaging and computational analysis enable more reproducible studies of cortical sulci [2]. Here we apply a taxon-free approach, offering new insights into the tempo and mode of cerebral reorganisation in early hominins.

We analysed 58 fossil hominin endocasts attributed to *Australopithecus*, *Paranthropus*, and *Homo*, spanning ~3.7 to 0.2 million years ago and originating from sites across southern and eastern Africa and Europe. Endocasts were digitised using micro-CT and 3D surface scanning. Sulcal imprints were automatically detected using a crest line detection algorithm [3] and labelled with reference to previous literature (e.g., [4]). Sulcal patterns were compared across specimens, with a focus on the frontal and occipital lobes. We identified four morphotypes based on lunate sulcus placement and frontal sulcal configuration (e.g., fronto-orbital sulcus) that cover a large spectrum of variation from a more primitive condition, which presents a typical, "ape-like" sulcal configuration, to a fully derived sulcal pattern seen in modern humans. The two intermediate morphotypes include the posterior migration of the lunate sulcus and an increase in complexity of frontal sulci, as well as a clearly posteriorly positioned lunate sulcus and further frontal elaboration, such as a posteriorly migrated inferior precentral sulcus, respectively.

Southern African early hominins exhibit marked variability in lunate sulcus position, with examples from Makapansgat, Sterkfontein, and Swartkrans illustrating the diversity of sulcal configurations in this region. In contrast, eastern African hominins retained a more consistently primitive pattern. Frontal sulcal variation is also evident in *Australopithecus* from Sterkfontein Member 4, most notably Sts 25, which was assigned to a more derived morphotype. Additionally, the Dmanisi *Homo* specimens show sulcal imprints that combine primitive elements with features typical of more derived morphologies. The Drimolen *Homo* endocast, in contrast, was assigned to the more primitive morphotype, highlighting unexpected sulcal stasis in an early *Homo* specimen. These results challenge linear models of brain evolution and suggest that while some early *Homo* populations in Africa retained primitive sulcal patterns, the emergence of more derived cortical features may have occurred after dispersal into Eurasia.

We thank curators and colleagues in Pretoria, Johannesburg, Pelindaba, Zürich, and Paris for access to fossil material and scans. Special thanks to R. Holloway for endocast access. This research was supported by the DST-NRF, Wits University, AESOP+, CNRS (CPJ-Hominines), Claude Leon Foundation, CoE-Pal, IFAS, PHC Protea and the Harding Distinguished Postgraduate Scholarship Programme.

References: [1] Holloway, R.L., Broadfield, D.C., Yuan, M.S., 2004. The Human Fossil Record, Vol. 3. Wiley, New York. [2] de Jager, E.J., Risser, L., Mescam, M., Fonta, C., Beaudet, A., 2022. Sulci 3D mapping from human cranial endocasts: A powerful tool to study hominin brain evolution. *Human Brain Mapping*. 43, 4433–4443. [3] Yoshizawa, S., Belyaev, A., Yokota, H., Seidel, H.-P., 2008. Fast, robust, and faithful methods for detecting crest lines on meshes. *Computer Aided Geometric Design*. 25, 545–560. [4] Connolly, C.J., 1950. External Morphology of the Primate Brain. C.C. Thomas, Springfield.

Poster Presentation Number 42, Session 1, Thursday 14:00 - 15:30

## Deciphering the locomotion of *Homo naledi* using trabecular and joint proportions

Yvonne de Rijk<sup>1</sup>, Jaap Saers<sup>2</sup>

1 - Institute of Biology, Leiden University, The Netherlands · 2 - Department of Anthropology, Emory University, Atlanta, USA

In contrast to all other living ape species, humans are the only living apes that do not rely on arboreal locomotion to survive. The body plan of these different living apes reflects various traits associated with the different locomotor types. It is important to understand the locomotor type of extinct hominin species because it gives us a piece in the puzzle of understanding the evolution of the human locomotion and get closer to the question on how *H. sapiens* became the only fully terrestrial biped.

In this study we aimed to decipher the locomotion type of *H. naledi*. *Homo naledi* shows a mosaic of anatomical adaptations. Especially the lower body shows traits for terrestrial bipedalism, but the upper body still includes various ancestral traits associated with climbing. This mosaic of traits is in itself already special, as *H. naledi* is a relatively young hominin species (living around 335–236 ka) [1], but still includes these ancestral climbing traits. Deciphering their locomotion was done using two approaches, comparing 1) the canalized trait joint proportions that are associated with locomotor behaviour in modern apes [2] and 2) two properties of the plastic trait trabecular bone, the bone volume fraction (BV/TV) and the degree of anisotropy (DA) of the extinct hominins to extant ape species with different locomotor behaviours. The different locomotor behaviours range from the fully terrestrial bipedal *Homo sapiens* to the intermediate *Gorilla gorilla*, *Pan troglodytes* to the fully arboreal *Pongo pygmaeus*, *Hylobates lar* and *Symphalangus syndactylus*. These two approaches were both used because it will be useful to know if the results of these approaches come to the same conclusion. Will the canalized trait joint proportions, which will give information about the evolutionary history and the plastic traits of the trabecular bone, which will give information about possible behaviour during life give us the same results?

For the joint proportion analysis, the resampling method of Green et al. [2] was used to account for the limited fossil record and the mean relative size index (RLSI) was used to compare the different species. For the trabecular bone analysis micro-CT scans were segmented using the Deep Learning tools of ORS DragonFly [3]. Then both trabecular properties were calculated within six volumes of interest (VOIs) throughout the talus also using ORS DragonFly.

Interestingly, the data from the two approaches show different results. The joint proportions of *H. naledi* do not significantly differ from that of *H. sapiens*, however the trabecular properties do differ between *H. naledi* and *H. sapiens*. The trabecular bone properties of *H. naledi* seem to fall outside of the range of any of the extant species used. The joint proportions thus indicate a locomotor pattern the same as *H. sapiens*, whereas the trabecular bone shows a pattern different from all the extant apes used. Combining this data, we argue that *H. naledi* exhibited a locomotor pattern that is different from any locomotor patterns that we see today, which most likely included both terrestrial bipedal walking and climbing. These results add to the growing knowledge about the various hominin locomotor behaviours and concludes that hominin locomotor diversity continued to exist into the late Pleistocene, contradictory to the belief that hominin locomotor evolution was always towards a fully terrestrial bipedal species.

References: [1] Dirks, P.H., Roberts, E.M., Hilbert-Wolf, H., Kramers, J.D., Hawks, J., Dosseto, A., Duval, M., Elliott, M., Evans, M., Grün, R., Hellstrom, J., Herries, A.L., Joannes-Boyau, R., Makhubela, T.V., Placzek, C.J., Robbins, J., Spandler, C., Wiersma, J., Woodhead, J., Berger, L.R., 2017. The age of *Homo naledi* and associated sediments in the Rising Star Cave, South Africa. *eLife*. 6. [2] Green, D.J., Gordon, A.D., Richmond, B.G., 2007. Limb-size proportions in *Australopithecus afarensis* and *Australopithecus africanus*. *Journal of Human Evolution*. 52, 187–200. [3] Comet Technologies Canada Inc., Montreal, Canada; software available at <https://www.theobjects.com/dragonfly>.

Pecha Kucha Presentation Number 5, Session 0, day 00:00

## Dusting off the oldest fossils: a re-examination of the temporal bone from Castel di Guido (Italy)

Antonietta Del Bove<sup>1,2</sup>, Antonino Vazzana<sup>1</sup>, Hila May<sup>3</sup>, Katerina Harvati<sup>4,5</sup>, Daniele Panetta<sup>6</sup>, Eugenio Bortolini<sup>1</sup>, Stefano Benazzi<sup>1</sup>

1 - Department of Cultural Heritage, University of Bologna, Italy · 2 - Catalan Institute of Human Paleoecology and Social Evolution, Spain · 3 - Department of Anatomy and Anthropology, the Dan David Center for Human Evolution and Biohistory Research, Gray Faculty of Medical and Health Sciences, Tel-Aviv · 4 - Paleoanthropology, Institute for Archaeological Sciences and Senckenberg Center for Human Evolution and Paleoecology, Department of Geosciences, Eberhard-Karls-Universität Tübingen, Germany · 5 - DFG Center 'Words, Bones, Genes, Tools', Eberhard-Karls-Universität Tübingen, Germany · 6 - Institute of Clinical Physiology - CNR Pisa, Italy

Castel di Guido is a Middle Pleistocene site located in the northwest of Rome, Italy. Recent chronological analyses place it within a temporal range between  $>381.0 \pm 1.9$  ka and  $\leq 394.8 \pm 2.6$  ka [1]. Discovered in 1979 through surface survey, the site was systematically excavated between 1980 and 1990. The excavated area, covering approximately 1100 m<sup>2</sup>, consists of deposits likely of fluvial origin and has yielded a substantial assemblage of artifacts, as well as faunal and human remains [2]. The faunal assemblage exhibits numerous cut marks and, together with the lithic industry, supports the interpretation of the site as a specialized hunting locality, likely dedicated to the accumulation and systematic butchering of animal carcasses [3,4]. Seven fragments of human cranial and postcranial bones have been recovered from different areas of the site. These include two femoral shafts (Castel di Guido-1 [CdG-1] and CdG-2), an occipital fragment (CdG-3), a right maxilla (CdG-4), a portion of the right parietal (CdG-5), a right temporal bone (CdG-6), and a fragment of the left parietal vault (CdG-7). Due to the fragmentary nature of the elements analysed, previous studies suggest that the Castel di Guido human remains exhibit a combination of plesiomorphic (archaic) and apomorphic (derived) morphological features [4]. The principal aim of this project is to re-examine the temporal bone (CdG-6) using a virtual anthropology approach and geometric morphometric (GM) methods, to provide a detailed morphological description of the temporal bones as a potential proxy for species-level classification. Temporal bone morphology has been shown to differentiate well between Neanderthals and modern humans [5] and has great potential to shed light on the assemblages' affinities.

To address these questions, we assembled a comparative dataset from multiple repositories, comprising key hominin taxa from the Middle Pleistocene to present time. These include *H. erectus* (*sensu lato*), *H. heidelbergensis*, *H. neanderthalensis*, and both archaic and anatomically modern *H. sapiens*. We acquired the external right temporal bone surface morphology of each specimen (for a total of 40 individuals) using 3D models generated via micro-computer tomography (micro-CT) and standard Ct scanning. When the right temporal bone was not preserved, the left one was mirrored using Geomagic Design X software. Morphological data were captured using configurations of six anatomical landmarks, two curves, and one patch of 100 surface semilandmarks. Given the fossil preservation state, missing landmarks were estimated using the TPS interpolant function implemented in the Morpho package in R. A semilandmark template was projected and slid across all specimens in the sample using the above-mentioned R package. With regard to the multivariate statistical analyses, these were also conducted using the R programming language. Generalized Procrustes Analysis (GPA) was performed using the geomorph package. The resulting aligned coordinates were then visualized through Principal Component Analysis (PCA), also implemented via geomorph. Permutation tests were carried out to assess group differences, using the RRPP package. Finally, a Linear Discriminant Analysis (LDA) was conducted using the MASS package.

The application of geometric morphometrics (GM) in this study provides an opportunity to construct the morphospace of the temporal bone, incorporating the CdG-6 specimen, a key fossil that may contribute to clarifying the complexity of cranial morphological variation observed during the Middle Pleistocene. Notably, and in accordance with other contemporary fossils, the CdG-6 specimen appears to align more closely with apomorphic (derived) forms than with plesiomorphic (ancestral) ones. This observation is consistent with the broader interpretative framework described by the expression 'muddle in the middle,' which refers to the challenges associated with the taxonomic classification of human fossils within the chronological and geographical scope of the European Middle Pleistocene, as supported by the present analyses.

The research is funded by the support of PRIN 2022 research project titled "HABITS - Life-histories of prehistoric human groups in South America: a tale on environmental adaptations and subsistence economies", Project Code 2022BC2Z5F\_001, CUP J53D23000140001, coordinated by Dr. Eugenio Bortolini for the Alma Mater Studiorum – University of Bologna. The project is funded under the National Recovery and Resilience Plan (PNRR) - Mission 4 – Component 2 – Investment 1.1 "Fund for the National Research Program and Projects of Significant National Interest (PRIN)" (Call issued by Ministerial Decree of the Ministry of University and Research No. 104 dated 02/02/2022). Furthermore, I gratefully acknowledge the support of "Eco-Social behaviour of the Sierra de Atapuerca Hominins during Quaternary, VI. PI: Dr M. Mosquera, Dr E. Carbonell PID2021-122355NB-C32. The ERC-AdG-101019659 supports Harvati and Benazzi. We would like to thank the Musée de l'Homme in Paris for providing the reference samples, and its curators, Prof. Dominique Grimaud Hervé and Prof. Antoine Balzeau, for their support.

References: [1] Marra F., Pereira A., Boschian G., Nomade S., 2022. MIS 13 and MIS 11 aggradational successions of the Paleo-Tiber delta: Geochronological constraints to sea-level fluctuations and to the Acheulean sites of Castel di Guido and Malagrotta (Rome, Italy). *Quaternary International*. 616, 1-11. [2] Radmilli, A.M., Boschian, G., 1996. Note Geoarcheologiche. In: Radmilli, A.M., Boschian, G. (Eds.) *Gli scavi a Castel di Guido. Il piu' antico giacimento di cacciatori del Paleolitico inferiore nell'Agro Romano*, Firenze, Istituto Italiano di Preistoria e Protostoria, p. 31-48. [3] Radmilli, A.M., Boschian, G., 1996. Le caratteristiche del giacimento di Castel di Guido e la sua posizione nell'ambito del Paleolitico Inferiore laziale. In: Radmilli, A.M., Boschian, G. (Eds.) *Gli scavi a Castel di Guido. Il piu' antico giacimento di cacciatori del Paleolitico inferiore nell'Agro Romano*, Firenze, Istituto Italiano di Preistoria e Protostoria, p. 165-173. [4] Sala, B., Barbi, G., 1996. Descrizione della fauna. In:

Radmilli, A.M., Boschian, G. (Eds.) Gli scavi a Castel di Guido. Il piu' antico giacimento di cacciatori del Paleolitico inferiore nell'Agro Romano, Firenze, Istituto Italiano di Preistoria e Protostoria, p. 55-90. [5] Mallegni, F., Mariani-Costantini, R., Fornaciari, G., Longo, E.T., Giacobini, G., Radmilli, A.M., 1983. New European fossil hominid material from an Acheulean site near Rome. *American Journal of Physical Anthropology*. 62, 263-274.

Poster Presentation Number 44, Session 1, Thursday 14:00 - 15:30

## From metamorphism to lithics: quartzite procurement areas at the Palaeolithic site of Ruidera (Ciudad Real, Spain)

Sara Díaz-Pérez<sup>1</sup>, Carlos A. Palancar<sup>2</sup>, Marcos Terradillos Bernal<sup>3</sup>, Lucía Bermejo Albarrán<sup>4</sup>, Isidoro Campaña Lozano<sup>5</sup>, Daniel García-Martínez<sup>6,7,8</sup>

1 - Institute of Archaeology, University of Wrocław, Wrocław, Poland · 2 - Grupo de Paleoantropología, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (MNCN - CSIC) · 3 - Universidad Isabel I de Castilla, Burgos, Spain · 4 - PATRICIA. Unidad de Investigación y Transferencia en Ciencias del Patrimonio. Universidad de Córdoba, Córdoba, Spain · 5 - Department of Ecology and Geology, Faculty of Sciences, Universidad de Málaga, Spain Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 6 - Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 7 - Laboratory of Forensic Anthropology, Centre for Functional Ecology, Department of Life Sciences, Universidade de Coimbra, Coimbra, Portugal · 8 - CENIEH (National Research Center on Human Evolution), Paseo de la Sierra de Atapuerca 3, Burgos, Spain

Palaeolithic industries on the Iberian Peninsula are characterised by the use of different raw materials for the manufacture of various types of lithics tools. In the central region of the Peninsula, particularly in the area known as La Mancha (Ciudad Real, Spain), several sites have been identified where quartzite was predominantly used. The reliance on this metamorphic rock as the primary raw material for lithic tool production invites reflection on the adaptive strategies and behaviour of Palaeolithic societies. Lithic tools can be considered both spatial and cultural markers, and their production reflects anthropic transformation. As such, these tools serve not only as functional implements but also as transmitters of cultural information and indicators of group mobility [1].

For this reason, in relation to the lithic industry found at the Ruidera site, an archaeo-paleontological site from the Middle Pleistocene, located in the Lagunas de Ruidera Natural Park, with a fossil assemblage dated between 300 and 400 ka, including faunal remains, human fossils, and lithic artifacts, made on quartzite cobbles [2], and considering that no raw material sources have been located in the surrounding area. We decided through Geographic Information Systems (GIS) modelling and a series of field surveys to identify potential supply zones from which the necessary resources for lithic production could have been obtained. These sites comprise extensive areas located less than 10 km from the main Ruidera site, covered with a wide variety of medium to fine-grained quartzite cobbles suitable for knapping. A diverse array of lithic artefacts has also been recovered from these zones, primarily made from such cobbles and displaying a broad range of reduction sequences, unifacial and bifacial.

The sourcing of local raw materials, particularly quartzite cobbles, in open-air contexts is a consistent pattern across various areas of La Mancha. This suggests that quartzite cobble collection and knapping activities were routinely conducted near the outcrops where these materials naturally occur. Consequently, a re-evaluation of these catchment areas, along with the study of newly identified surface materials and the analysis of archaeological assemblages from the Ruidera site, will provide valuable insights into the procurement and exploitation strategies employed by Palaeolithic human groups inhabiting the area surrounding the Lagunas de Ruidera.

This research is funded by Leakey Foundation project ID: 45148 (2024-2025) entitled "Paleoanthropological investigation at Ruidera-Los Villares: Deciphering Middle Pleistocene Enigma in Western Europe"; and also, by Fundación PALARQ project entitled "Desvelando la Cronología del Pasado Humano: Análisis Multimétodo de Datación en el Yacimiento de Ruidera-Los Villares, Pleistoceno Medio". We acknowledge the neighbours and institutions from Ruidera for their hospitality as well as Junta de Comunidades de Castilla-La Mancha and Parque Natural de las Lagunas de Ruidera for awarding the permits for the excavation. We also want to acknowledge the entire excavation team for their great and selfless work.

References: [1] Mangado, J., 2006. El aprovisionamiento en materias primas líticas: Hacia una caracterización paleocultural de los comportamientos paleoeconómicos. *Trabajos de Prehistoria*. 63, 79–91. [2] García Martínez, D., Duval, M., Zhao, J., Feng, Y., Wood, R., Huguet, R., Cifuentes-Alcobendas, G., Palancar, C.A., Moya-Maleno, P.R., 2022. Los Villares locality (Ruidera, Castilla-La Mancha, Spain): a new Middle Pleistocene fossil assemblage from the Southern Iberian Plateau with possible evidence of human activity. *Cuaternario y Geomorfología*. 36, 7–35.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## Advancing enamel amino acid dating: innovations in methodology, application and sustainability

Marc R. Dickinson<sup>1</sup>, Laila Patinglag<sup>2</sup>, Mathieu Duval<sup>3</sup>, Kirsty Shaw<sup>2</sup>, Kirsty Penkman<sup>1</sup>

1- Department of Chemistry, University of York, United Kingdom · 2 - Manchester Metropolitan University, United Kingdom · 3 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Spain

Amino acid geochronology (AAG) of tooth enamel has emerged as a valuable technique for dating Quaternary fossils beyond the temporal limits of radiocarbon methods. The predictable breakdown of proteins and amino acids within the closed-system fraction of enamel presents a promising approach for the direct relative dating of mammalian remains from the past few million years [1]. These relative frameworks can then be calibrated using numerical dating techniques to provide additional age constraints. Enamel amino acid geochronologies based on proboscideans (elephants and mammoths), horses and bison have demonstrated robust dating frameworks which can be correlated to the climate record [2]. Here we report three methodological innovations: a microfluidics preparation method, the successful reuse of enamel powders taken for other analyses, and the removal of collagen-based consolidants from tooth enamel.

We have developed a novel microfluidics-based preparation method for enamel intra-crystalline protein decomposition dating (IcPD), designed to minimise sample size requirements and facilitate preparation outside of dedicated amino acid clean laboratories. This innovation enables sample processing within the country of origin, thereby reducing the need for complex export procedures and promoting more sustainable and inclusive research practices.

Many techniques used to acquire critical molecular information—whether for environmental reconstruction or to better understand the context of mammalian material—necessitate destructive sampling. The reuse of powders or residual material from such analyses not only mitigates the need for further destructive sampling, but also allows for more meaningful data comparisons from the same specimens. We investigated the impact of gamma irradiation, commonly employed in electron spin resonance (ESR) dating, on amino acid breakdown, assessing the feasibility of repurposing ESR residual powders for IcPD analysis. This approach offers the potential to establish key chronological tie-points, anchoring relative dating frameworks generated through AAG to absolute timescales. In addition, we examine the effects of collagen-based adhesives—frequently used in the historical conservation of specimens—on amino acid integrity, highlighting the importance of rigorous contamination screening when working with legacy collections. Finally, we explore the broader taxonomic applicability of enamel IcPD, assessing its utility across a range of faunal groups found in Palaeolithic archaeological contexts.

Taken together, these developments enhance the accuracy, versatility, and applicability of enamel AAG, supporting its role as a useful tool for chronological reconstruction in palaeoanthropology and Quaternary science.

This project (EQuaTe) has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 865222).

References: [1] Dickinson, M.R., Lister, A.M., Penkman, K.E.H., 2019. A new method for enamel amino acid racemization dating: A closed system approach. *Quaternary Geochronology*. 50, 29–46. [2] Dickinson, M.R., Scott, K., Adams, N.F., Lister, A.M., Penkman, K.E.H., 2024. Amino acid dating of Pleistocene mammalian enamel from the River Thames terrace sequence: a multi-taxon approach. *Quaternary Geochronology*. 82, 101543.

Podium Presentation, Session 7, Saturday 08:30 – 10:30

## First documentation and quantification of wild chimpanzee rock climbing: a comparison to tree climbing and insights to hominin evolution

Rhianna C. Drummond-Clarke<sup>1</sup>, Charlotte King<sup>1</sup>, T. L. Kivell<sup>1</sup>, Catherine Hobaiter<sup>2</sup>, Alex K. Piel<sup>1,3,4</sup>, Liran Samuni<sup>5</sup>, Fiona. A. Stewart<sup>1,3,4</sup>, Erin. G. Wessling<sup>5</sup>, Joram Lazaro Navayo<sup>4</sup>, Adam Van Casteren<sup>1</sup>

1 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 2 - School of Psychology & Neuroscience, University of St Andrews, St Andrews, UK · 3 Department of Anthropology, University College London, London, UK · 4 GMERC Ltd., Mpanda, Tanzania · 5 German Primate Center, Göttingen, Germany

The emergence and evolution of habitual bipedalism is traditionally associated with increased terrestriality as hominins adapted to more open habitats. However, multiple hominin species exhibit forelimb morphology advantageous for arboreal locomotion, generating debate over the functional significance of these features and the adaptive niche in which hominins evolved. Recently, rock climbing, perhaps in addition to tree climbing, has been proposed as a driver for the retention of hominin climbing adaptations in rugged, open habitats [1,2]. However, due to a lack of studies on non-human primates [3], we have limited biomechanical data to benchmark how arboreal climbing adaptations (e.g., long, curved phalanges, high forelimb-hindlimb ratio) support or influence rock climbing. Here, we present the first known report and quantification of chimpanzee rock climbing in the wild, comparing limb-substrate contact duration and limb position during rock vs tree climbing in two populations. We test the predictions that (1) limb-substrate contact duration, measured by duty factor (DF; the proportion of time each limb is in contact with the substrate during a stride) and four-limb contact cycle duration (the absolute time to complete one full movement cycle of all four limbs) will be longer when rock climbing due to navigating more unpredictable/uneven surfaces, and (2) more extension/flexion of the limb joints will be required when rock climbing to reach specific holds.

Rock climbing data were collected between 2023–2025 using 4k camera traps in two savannah-mosaic chimpanzee sites that resemble the reconstructed palaeohabitats of some Pliocene hominins, characterised by open vegetation and rugged terrain [4]: Issa Valley, Tanzania (*Pan troglodytes schweinfurthii*), and Moyen Bafing, Guinea (*P. t. verus*). Tree climbing bouts were video recorded opportunistically during behavioural follows of the habituated community at Issa in 2020 and 2023. We analysed a minimum of 10 bouts of each vertical ascent climbing on rock faces, and vertical ascent and descent on arboreal substrates. Video frames were extracted, the frame numbers of touchdown/lift-off events during one four-limb contact cycle (starting with left forelimb touchdown, ending with the last of the four limbs to liftoff) recorded, and the DF and cycle duration calculated from the camera frame rate. Limb position was compared as the proportion of forelimb touchdown events with the shoulder abducted and elbow extended, hindlimb touchdowns with the hip and knee fully flexed, and hindlimb liftoffs with the hip and knee fully extended. Means were compared by substrate and direction climbed.

Contrary to expectations, we found DF was significantly lower during rock compared to tree climbing, regardless of direction climbed. Four-limb contact cycle duration was, however, significantly longer during rock climbing. Rock climbing was also more variable in footfall pattern, and may involve greater limb joint excursion angles as well as orthograde hindlimb-compressive locomotor modes not yet described for primates [5]. Our preliminary findings suggest that chimpanzees may use more dynamic movements between stable positions when rock vs tree climbing, which could be a consequence of constrained and uneven route options offered by rock faces. Further research on a larger sample, including multiple strides with quantification of limb kinematics, rock face characteristics (i.e., angle, holds used) will be informative to investigate how arboreal climbing adaptations could facilitate this climbing technique. Through improving our understanding of the ecological context and kinematics of rock climbing in a large-bodied ape in their natural habitat, our results begin to inform our understanding of the role of rock climbing in shaping the hominin skeleton; specifically, the retention of morphological adaptations for climbing combined with habitual bipedalism in open, rugged landscapes.

We give special thanks to the field teams at Greater Mahale Ecosystem Research and Conservation (GMERC) and Moyen Bafing Chimpanzee Project (MBCP) for field support. We thank the Tanzania Wildlife Research Institute (TAWIRI), the Commission for Science and Technology (COSTECH), and the Mpanda District government for granting permission to conduct research in Tanzania. We thank the Ministère de l'Environnement et du Développement Durable en Guinée and the Office Guinéen des Parcs Nationaux et Réserves de Faunes (OGPNRF) for permission to conduct research in the Moyen Bafing National Park. We thank the UCSD/Salk Center for Academic Research and Training in Anthropogeny (CARTA) and the Max Planck Society for support of GMERC, and the Wild Chimpanzee Foundation, the Leakey Foundation (LS, EW), DFG Emmy Noether Program (LS), and the European Research Council (CH) for support of MBCP. This research was supported by the Leakey Foundation Research Grant (RCDC).

References: [1] Dunmore, C.J., Skinner, M.M., Bardo, A., Berger, L.R., Hublin, J.-J., Pahr, D.H., Rosas, A., Stephens, N.B., Kivell, T.L., 2020. The position of *Australopithecus sediba* within fossil hominin hand use diversity. *Nature Ecology and Evolution*, 4, 911–918. [2] Voisin, J.L., Feuerriegel, E.M., Churchill, S.E., Berger, L.R., 2020. The *Homo naledi* shoulder girdle: An adaptation to boulder climbing. *L'anthropologie*, 124, 102783. [3] Everett, M.C., Elliot, M.C., Gaynor, D., Hill, A., Syeda, S.M., Casana, J., Zipfel, B., DeSilva, J.M., Dominy, N.J., 2021. Mechanical loading of primate fingers on vertical rock surfaces. *South African Journal of Science*, 117, 10409. [4] Reynolds, S.C., Bailey, G.N., King, G.C.P., 2011. Landscapes and their relation to hominin habitats: Case studies from *Australopithecus* sites in eastern and southern Africa. *Journal of Human Evolution*, 60, 281–298. [5] Hunt, K.D., Cant, J.G.H., Gebo, D.L., Rose, M.D., Walker, S.E., Youlatos, D., 1996. Standardized descriptions of primate locomotor and postural modes. *Primates* 37, 363–387.

Podium Presentation, Session 4, Friday 08:30 – 10:30

## Slugs and snails: a novel luminescence dating method applied to Palaeolithic sites in central and northern France

Geoff A.T. Duller<sup>1</sup>, Debra Colarossi<sup>1</sup>, Helen M. Roberts<sup>1</sup>, Pierre Antoine<sup>2</sup>, Julie Dabkowski<sup>2</sup>, Marc Dickinson<sup>3</sup>, Nicole Limondin-Lozouet<sup>2</sup>, Ellie F. Nelson<sup>3</sup>, Richard C. Preece<sup>4</sup>, Dustin White<sup>3</sup>, Kirsty E.H. Penkman<sup>3</sup>

1 - Department of Geography, Aberystwyth University, UK · 2 - CNRS, Laboratoire de Géographie Physique, UMR8591 Université Paris 1 Panthéon-Sorbonne, Université Paris Est-Créteil, Thiais, France · 3 - Department of Chemistry, University of York, UK · 4 - Department of Zoology, University of Cambridge, UK

The record of hominin activity in Europe extends back to the early Pleistocene, and preserves a complex record spatially and temporally. Most sites provide brief snapshots in time, and piecing together this disparate record depends upon being able to place the sites in chronological order. The ERC-funded EQuaTe project seeks to provide an overarching chronology for key Palaeolithic sites across northern Europe covering the last 2 Ma, and is underpinned by the application and development of two complementary dating methods to improve the chronology of this archaeological record: (1) intracrystalline-protein decomposition (IcPD) for amino acid geochronology and (2) thermoluminescence (TL) analysis of biogenic calcite. IcPD is becoming well established and provides a relative chronological framework throughout this time period (e.g. [1]). TL analysis of biogenic calcite has been discussed for a number of years [2] but has not previously been able to provide numerical ages. As part of the EQuaTe project the ability to date calcite formed by biological processes has been developed (e.g. [3]).

Calcite has a bright thermoluminescence (TL) signal which has the capability to date events as far back as a few million years [4]. The primary biogenic calcite targeted in EQuaTe for TL dating has been the opercula of the gastropod *Bithynia tentaculata* [5], but slug plates of the Limacidae family have also proved ideal materials for TL dating. The results of this exciting new method for samples of slug plates and *B. tentaculata* opercula will be presented for the Middle and Late Pleistocene sites of La Celle, Resson and Caours in central and northern France, and discussed in the context of other dating methods applied to these sites. TL dating of biogenic calcite offers a valuable new numerical dating method capable of spanning the entire Pleistocene and evolution of the genus *Homo*.

The EQuaTe project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 865222).

References: [1] Nelson, E., Püspöki, Z., White, D., Pogácsás, G., McIntosh, R.W., Szappanos, B., Wheeler, L., Fancsik, T., Penkman, K., 2024. A Quaternary aminostratigraphy for the Pannonian Basin: The competing influences of time, burial depth and temperature in deep-core material. *Quaternary Science Reviews*. 346, 109044. [2] Duller, G.A.T., Kook, M., Stirling, R.J., Roberts, H.M., Murray, A.S., 2015. Spatially-resolved thermoluminescence from snail opercula using an EMCCD. *Radiation Measurements*. 81, 157–162. [3] Colarossi, D., Duller, G.A.T., Roberts, H.M., Stirling, R.J., Penkman, K.E.H., 2025. The effect of light exposure on the thermoluminescence signal from calcitic opercula. *Radiation Measurements*. 183, 107417. [4] Duller, G.A.T., Roberts, H.M., 2018. Seeing Snails in a New Light. *Elements*. 14, 39–43. [5] Penkman, K.E.H., Duller, G.A.T., Roberts, H.M., Colarossi, D., Dickinson, M.R., White, D., 2022. Dating the Paleolithic: Trapped charge methods and amino acid geochronology. *Proceedings of the National Academy of Sciences*. 119.

Poster Presentation Number 45, Session 1, Thursday 14:00 - 15:30

## Decoding the dietary habits of ancient primates: molar microtexture and dietary reconstruction of fossil Cercopithecoidea from Olduvai Gorge, Tanzania

Albert E. Dyowe Roig<sup>1</sup>, Luís Hidalgo-Trujillo<sup>1,2</sup>, Ferran Estebarez-Sánchez<sup>1</sup>, Juan José Ibáñez<sup>3</sup>, Ignacio De la Torre<sup>4</sup>, Jackson K. Njau<sup>5</sup>, Laura M. Martínez<sup>1,2</sup>

1 - Departament de Biologia Evolutiva, Ecologia i CCAA, Facultat de Biologia, Universitat de Barcelona, Spain · 2 - Institut d'Arqueologia de la Universitat de Barcelona, Spain · 3 - Institució Milà i Fontanals, Consejo Superior de Investigaciones Científicas (IMF-CSIC), Barcelona, Spain · 4 - CSIC-Spanish National Research Council, Madrid, Spain · 5 - Indiana University, USA

Cercopithecoidea fossils are extensively represented in the Plio-Pleistocene fossil record of eastern and southern African sites, reflecting their ecological success and adaptability during a period of multiple climatic and environmental fluctuations [1]. The genus *Theropithecus* sp. is distinguished as a particularly successful Papionini lineage during the African Neogene, with a temporal range extending from at least 3.7-0.25 Ma and a widespread geographical distribution across North, East and South African sites. The evolutionary history of *Theropithecus* is closely linked to these regional climatic oscillations, which likely influenced dispersal and radiation, the availability of dietary resources, and competition with other cercopithecoids, such as *Papio*. In this context, the assessment of the dietary flexibility of Papionini species is pivotal to understanding their adaptability to environmental change. This is particularly evident when comparing the ecological versatility of *Papio* with the progressive ecological narrowing of *Theropithecus* over time. Comprehending the paleoecological and dietary reconstruction of these taxa across various African sites is key to elucidating their evolutionary history.

The present study focuses on the feeding ecology of fossil Papionini from Olduvai Gorge, where several extinct taxa have been described from Bed I and Bed II. The analysis of dental microtexture patterns in two species of terrestrial Papionini (*Papio* sp. and *Theropithecus oswaldi*) was conducted to infer dietary signals and to determine whether *Theropithecus* and *Papio* exploited analogous dietary resources within the same ecosystems or occupied distinct ecological niches. Dental replicas were obtained from the original specimens curated in the Leakey Collection in Dar es Salaam (Tanzania), resulting in a final sample of 12 molars from *Papio* sp. and 42 molars from *Theropithecus oswaldi*. The analysis of surface texture was conducted using a Sensofar Plu Neo confocal microscope. Thirty-eight ISO 25178 parameters were extracted using Mountains® v.10 software following standardised protocols. The fossil specimen was compared to a baseline of extant Cercopithecoidea species, which exhibited a wide dietary spectrum [2].

The results obtained from the analysis indicate that *Theropithecus oswaldi* and *Papio* sp. from Olduvai exhibit abrasive buccal microtexture patterns, which are similar to those observed in *Papio hamadryas* and *Mandrillus sphinx*. These species forage in savannas and open woodlands and exploit rough items. These patterns differ from those of extant graminivorous *Theropithecus gelada*. The buccal surfaces of the fossil specimens of *Theropithecus* and *Papio* are characterised by the presence of coarse microstriations and high dale volume, which are indicative of the consumption of mechanically challenging food items.

These findings suggest that both taxa relied significantly on abrasive dietary resources, providing new insights into the ecological strategies and paleoecology of Papionini during the Plio-Pleistocene.

This research has received funding from MCIU/AEI/10.13039/501100011033 PID2023-148818NB-I00 to LMM and funding of European Research Council-Advanced Grants (BICAEHFID, No. 832980)

References: [1] Elton, S., 2007. Environmental correlates of the Cercopithecoid radiations. *Folia Primatologica*. 78, 344–364. [2] Martínez, L.M., Estebarez-Sánchez, F., Romero, A., Ibáñez, J.J., Hidalgo-Trujillo, L., Avià, Y., Pérez-Pérez, A., 2022. Effectiveness of buccal dental-microwear texture in African Cercopithecoidea dietary discrimination. *American Journal of Biological Anthropology*. 179, 678–686.

Poster Presentation Number 46, Session 1, Thursday 14:00 - 15:30

## Diploic vein morphology in Upper Palaeolithic humans

Stanislava Eisová<sup>1,2,3</sup>, Rebeka Rmoutilová<sup>4</sup>, Jaroslav Brůžek<sup>4</sup>, Petr Velemínský<sup>1</sup>

1 - The Department of Anatomy and Anthropology, School of Medicine, Gray Faculty of Medical & Health Sciences, Tel-Aviv University, Israel · 2 - The Dan David Center for Human Evolution and Biohistory Research, Faculty of Medical & Health Sciences, Tel-Aviv University, Israel · 3 - Department of Anthropology, Natural History Museum, National Museum, Prague, Czech Republic · 4 - Department of Anthropology and Human Genetics, Faculty of Science, Charles University, Prague, Czech Republic

The vascular system of the human head consists of networks that bridge the endocranial and ectocranial spaces. Beyond internal cerebral circulation and external scalp drainage, it includes the diploic veins, located within the diploe of the cranial vault bones. These veins form canals within the diploe and connect with other vessels, such as the middle meningeal vessels and dural venous sinuses. In palaeoanthropology and bioarchaeology, craniovascular traits provide the only available evidence of vascular networks in extinct hominins and past populations, offering insights into physiological processes related to blood circulation and possibly brain evolutionary adaptations [1].

This study examines diploic morphological patterns in a sample of Upper Palaeolithic (UP) individuals and compares them to recent cranial samples. It also investigates the diploic veins in a ~45,000-year-old fossil cranium from Zlatý kůň (Koněprusy Caves, Czech Republic), which is thought to represent one of the earliest modern human populations in Europe [2,3]. The UP sample includes individuals from the Early UP (EUP, N=7), Middle UP (MUP, N=8), and Late UP (LUP, N=2) periods. The control group consists of recent individuals from the 19th–20th century Czech Republic (N=80) [4]. Diploic vein morphology was visualized using CT scans in 3D Slicer, and the patterns and sizes of major diploic channels were assessed following a previously established methodology [5].

The UP samples exhibited more frontal, fewer parietal, and a similar number of occipital diploic channels compared to the recent sample. The average diameters of the diploic channels were smaller in the UP sample, especially in the parietal and occipital bones, where also the largest channels were notably smaller. The cumulative indexes for the parietal and occipital diploic veins—reflecting the potential volume of blood flow through the macroscopic diploic network—were also lower in the UP individuals than in the recent sample. Focusing on the Zlatý kůň cranium, although it is missing most of its left side, it revealed a complex diploic network: at least one large frontal channel, several crossing channels in the right parietal bone (and at least one on the left), and two vertical occipital channels bilaterally. Its DV morphology most closely resembled that of the EUP sample, consistent with its age and classification within this period.

These similarities between Zlatý kůň and the EUP sample align with earlier analyses of the middle meningeal vessels and dural venous sinuses, which also showed the closest resemblance to the EUP group and support previous studies suggesting affinities with pre-LGM humans [3]. The differences observed between the UP and recent samples may be attributed to a combination of genetic and environmental factors [1,2]. Overall, this study provides further evidence that diploic morphological features varied across time and region and suggests that, with further research and additional data on diploic and other craniovascular traits in past populations, these features might offer an additional means for assessing affinities in palaeoanthropology and bioarchaeology.

This study was funded by the Ministry of Culture of the Czech Republic (grant number DKRVO 2024-2028/7.I.b, 00023272, National Museum).

References: [1] Pišová, H., Rangel de Lázaro, G., Velemínský, P., Bruner, E., 2017. Craniovascular traits in anthropology and evolution: from bones to vessels. *Journal of Anthropological Sciences*, 95, 35–65. [2] Prüfer, K., Posth, C., Yu, H., Stössel, A., Spyrou, M.A., Deviese, T., Mattoni, M., Ribechini, E., Higham, T., Velemínský, P., Brůžek, J., Krause, J., 2021. A genome sequence from a modern human skull over 45,000 years old from Zlatý kůň in Czechia. *Nature Ecology & Evolution*, 5, 820–825. [3] Rmoutilová, R., Guyomarc'h, P., Velemínský, P., Šefčíková, A., Samsel, M., Santos, F., Maureille, B., Brůžek, J., 2018. Virtual reconstruction of the Upper Palaeolithic skull from Zlatý kůň, Czech Republic: sex assessment and morphological affinity. *PLOS ONE*, 13, e0201431. [4] Eisová, S., Velemínský, P., Velemínská, J., Bruner, E., 2022. Diploic vein morphology in normal and craniostenotic adult human skulls. *Journal of Morphology*, 283, 1318–1336. [5] Rangel de Lázaro, G., Eisová, S., Pišová, H., Bruner, E., 2018. The endocranial vascular system: tracing vessels. In: Bruner, E., Ogihara, N., Tanabe, H. (Eds.), *Digital endocasts*, Springer, p. 71–91.

Poster Presentation Number 47, Session 1, Thursday 14:00 - 15:30

## Palaeoproteomic analysis of fauna from the *Homo heidelbergensis* type locality

Zandra Fagernäs<sup>1</sup>, Yun Chiang<sup>1</sup>, Viridiana Villa-Islas<sup>1</sup>, Gaudry Troché<sup>1</sup>, Marc Dickinson<sup>2</sup>, Samantha Greeves<sup>2</sup>, H. Dieter Schreiber<sup>3</sup>, Michael Wierer<sup>4</sup>, Jesper V. Olsen<sup>5</sup>, Matthew J. Collins<sup>1,6</sup>, Kirsty E.H. Penkman<sup>2</sup>, Oliver Friedrich<sup>7</sup>, Joerg Pross<sup>7</sup>, Frido Welker<sup>1</sup>

1 - Globe Institute, University of Copenhagen, Copenhagen, Denmark · 2 - Department of Chemistry, University of York, York, United Kingdom · 3 - State Museum of Natural History Karlsruhe, Karlsruhe, Germany · 4 - Proteomics Research Infrastructure, University of Copenhagen, Copenhagen, Denmark · 5 - Centre for Protein Research, University of Copenhagen, Copenhagen, Denmark · 6 - Department of Archaeology, University of Cambridge, Cambridge, United Kingdom · 7 - Institute of Earth Sciences, Heidelberg University, Heidelberg, Germany

The hominin mandible discovered at the Sandgrube Grafenrain, commonly known as the “Mauer mandible”, is generally considered essential for understanding Middle Pleistocene hominin evolution and diversity, as it is the type specimen of *Homo heidelbergensis* [1]. Dated to  $609 \pm 40$  ka [2], it falls within the Middle Pleistocene, a time period during which several hominin taxa were present in Eurasia. The classification of hominin fossils into these taxa and the evolutionary relationships between them have been the subject of considerable and continuous controversy [3]. Based on morphological analysis, it is currently widely debated whether *Homo heidelbergensis* is a valid hominin taxon and, if so, which hominin fossils would be placed in it. In addition, under a scenario of acceptance of the taxon, there are several hypotheses available on the relationship of the taxon to other hominin taxa [3]. Palaeoproteomic evidence from the type specimen of *H. heidelbergensis* has the potential to shed light on this issue in a manner that has thus far not been possible.

To explore the potential of ancient protein analysis of the Mauer mandible, we present here comparative amino acid racemisation (AAR) and palaeoproteomic analysis of associated faunal bone, dentine, and dental enamel specimens. AAR analysis utilised a reverse-phase high-pressure liquid chromatography (RP-HPLC) method with the isolation of an ‘intra-crystalline’ fraction of amino acids by bleach treatment for the dental enamel samples [4]. AAR analysis revealed low amino acid concentrations in bone and dentine, but an amino acid composition compatible with collagens, the major bone proteins. For dental enamel, AAR analysis revealed an amino acid concentration and composition similar to previously-analysed Pleistocene dental enamel samples, and exhibiting an extent of racemisation compatible with the proposed age of the Mauer mandible.

Next, we employed liquid-chromatography tandem mass spectrometry (LC-MS/MS) using a range of extraction methods on bone, dentine, and dental enamel [5]. We observe differences in extraction success depending on the extraction method utilised, including the recovery of endogenous proteins from most studied specimens. In particular, there is a consistent recovery of collagens and dental enamel proteins. Peptides deriving from these proteins contain elevated levels of damage and protein alteration, consistent with their Middle Pleistocene age, the AAR observations, and in agreement with previous palaeoproteomic studies on material of similar ages. The peptides recovered also retain phylogenetically informative amino acid sequences, allowing the recovery of taxonomic information for the studied faunal specimens. These results provide insights into protein preservation at the Sandgrube Grafenrain, and the possibility of conducting palaeoproteomic analysis on palaeontological and palaeoanthropological specimens of similar ages and preservation conditions for taxonomic and phylogenetic purposes.

This research has been made possible through funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme, grant agreement no. 948365 (PROSPER, awarded to F.W.). Amino acid racemisation research was supported by grants from the European Research Council, European Union's Horizon 2020 Research and Innovation Programme (865222) and the Natural Environment Research Council (NERC) (NE/S010211/1), awarded to K.E.H.P.

References: [1] Schoetensack, O., 1908. Der Unterkiefer des *Homo heidelbergensis* aus den Sanden von Mauer bei Heidelberg. Ein Beitrag zur Paläontologie des Menschen. Zeitschrift für Induktive Abstammungs- und Vererbungslehre. 1, 408–410. [2] Wagner, G.A., Krbetschek, M., Degering, D., Bahain, J.-J., Shao, Q., Falguères, C., Voinchet, P., Dolo, J.-M., Garcia, T., Rightmire, G.P., 2010. Radiometric dating of the type-site for *Homo heidelbergensis* at Mauer, Germany. Proceedings of the National Academy of Sciences. 107, 19726–19730. [3] Bae, C.J., Aiello, L.C., Hawks, J., Kaifu, Y., Lindal, J., Martínón-Torres, M., Ni, X., Posth, C., Radović, P., Reed, D., Schroeder, L., Schwartz, J.H., Silcox, M.T., Welker, F., Wu, X., Zanolli, C., Roksandic, M., 2023. Moving away from “the Muddle in the Middle” toward solving the Chibanian puzzle. Evolutionary Anthropology: Issues, News, and Reviews. 33. [4] Dickinson, M.R., Lister, A.M., Penkman, K.E.H., 2019. A new method for enamel amino acid racemization dating: A closed system approach. Quaternary Geochronology. 50, 29–46. [5] Tsutaya, T., Sawafuji, R., Taurozzi, A.J., Fagernäs, Z., Patramanis, I., Troché, G., Mackie, M., Gakuhari, T., Oota, H., Tsai, C.-H., Olsen, J.V., Kaifu, Y., Chang, C.-H., Cappellini, E., Welker, F., 2025. A male Denisovan mandible from Pleistocene Taiwan. Science. 388, 176–180.

Podium Presentation, Session 4, Friday 08:30 – 10:30

## Convergent technological trajectories in early modern humans across the Mediterranean: insights from the Ahmarian and Protoaurignacian

Armando Falcucci<sup>1,2,3</sup>, Steven L. Kuhn<sup>4</sup>

1 - Department of Geosciences, Prehistory and Archaeological Sciences Research Unit, Eberhard Karls University of Tübingen, Tübingen, Germany · 2 - Department of Anthropology, New York University, New York, New York, USA · 3 - Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour, Universidade do Algarve, Faro, Portugal · 4 - School of Anthropology, University of Arizona, Tucson, USA

The appearance of the Protoaurignacian in Europe around 42,000 years ago is widely believed to result from a major dispersal of early modern humans from the Levant, a view primarily supported by perceived similarities between stone tools assigned to the Mediterranean Protoaurignacian and the Levantine Ahmarian [1,2]. However, no comprehensive quantitative analysis has thoroughly tested this hypothesis. In this study, we address this longstanding assumption by providing the first systematic comparison of lithic technologies between Protoaurignacian assemblages in Italy (Grotta di Fumane [3], Riparo Bombrini [4], and Grotta di Castelcivita [5]) and the Ahmarian (layers XX–XVI) and post-Ahmarian (layers XIII–XI) at the key site of Ksar Akil (Lebanon). Using attribute analysis and multivariate statistics within the theoretical framework of the Behavioral Approach to Cultural Transmission by G. Tostevin, we assess technological similarities and differences across different stages of the core reduction sequence.

Our results show very limited technological affinities between the Protoaurignacian and both Ahmarian and post-Ahmarian lithic assemblages at Ksar Akil, challenging the notion that the Ahmarian is ancestral to the Protoaurignacian. For example, the Ahmarian at Ksar Akil is characterized by bidirectional core reduction aimed at blade production, while Protoaurignacian toolmakers focused almost exclusively on bladelet production from unidirectional volumetric cores. Although both regions exhibit marked trends of lithic miniaturization, notably visible in the stratigraphic transition to the post-Ahmarian layers at Ksar Akil, the core reduction procedures differ markedly. Layers XIII–XI at Ksar Akil are characterized by the production of twisted bladelets from carinated and burin cores, a trait uncommon in the Protoaurignacian.

Overall, these findings refute the hypothesis of a Levantine origin for the Protoaurignacian and suggest that technological convergence—driven by the rise of multi-component projectile technology and increased foraging mobility—played a central role in shaping the Early Upper Paleolithic. More broadly, our analysis underscores the need to reconsider diffusionist narratives in the biocultural evolution of early modern humans at the onset of the Upper Paleolithic, particularly as new findings continually push back dispersal timelines and paleogenetic studies show genetic admixture between different human lineages. We argue that, rather than a simple east-to-west diffusion of hominin populations and technologies, the development of the Protoaurignacian reflects parallel technological developments across the Mediterranean. In this framework, we discuss the importance of considering internal cultural dynamics and the need for more systematic investigations into the often-neglected links between the Protoaurignacian and the Châtelperronian.

AF would like to thank the staff of the Peabody Museum of Archaeology and Ethnology at Harvard University, particularly Laura Costello, for hosting his research stay and assisting with the analysis of the Ksar Akil assemblages. He is also grateful to Christina Warinner (Harvard University) and Kristine Korzow Richter (Texas A&M University) for providing access to the 3D scanner used to digitize the Ksar Akil lithic collections. The Protoaurignacian datasets, published under CC-BY-4.0, were generated by AF in collaboration with Adriana Moroni (University of Siena), Fabio Negrino (University of Genoa), Marco Peresani (University of Ferrara), and Julien Riel-Salvatore (University of Montreal). Finally, we would like to acknowledge Christian Tryon (University of Connecticut) for providing invaluable feedback on the sampling strategy of the Ksar Akil collections.

References: [1] Zilhão, J., d'Errico, F., Banks, W.E., Teyssandier, N., 2024. A Data-Driven Paradigm Shift for the Middle-to-Upper Palaeolithic Transition and the Neandertal Debate. *Quaternary Environments and Humans*. 2, 100037. [2] Slimak, L., 2023. The three waves: Rethinking the structure of the first Upper Paleolithic in Western Eurasia. *PLOS ONE*. 18, e0277444. [3] Falcucci, A., Giusti, D., Zangrossi, F., De Lorenzi, M., Ceregatti, L., Peresani, M., 2024. Refitting the Context: A Reconsideration of Cultural Change among Early *Homo sapiens* at Fumane Cave through Blade Break Connections, Spatial Taphonomy, and Lithic Technology. *Journal of Paleolithic Archaeology*. 8. [4] Falcucci, A., Arrighi, S., Spagnolo, V., Rossini, M., Higgins, O.A., Muttillio, B., Martini, I., Crezzini, J., Boschini, F., Ronchitelli, A., Moroni, A., 2024. A pre-Campanian Ignimbrite techno-cultural shift in the Aurignacian sequence of Grotta di Castelcivita, southern Italy. *Scientific Reports*. 14. [5] Falcucci, A. et al. A pre-Campanian Ignimbrite techno-cultural shift in the Aurignacian sequence of Grotta di Castelcivita, southern Italy. *Scientific Reports* 14, 12783, doi:10.1038/s41598-024-59896-6 (2024).

Podium Presentation, Session 7, Saturday 08:30 – 10:30

## Footwear impacts the trabecular architecture of the medial column of the human foot

Hannah N. Farrell<sup>1</sup>, Sebastian Bachmann<sup>2</sup>, Zewdi J. Tsegai<sup>1</sup>

1 - Department of Organismal Biology and Anatomy, University of Chicago, IL, USA · 2 - Institute of Lightweight Design and Structural Biomechanics, TU Wien, Vienna, Austria

The transition to bipedalism marks a major milestone in human evolution, yet fossil evidence suggests considerable variation in how bipedality was practiced. Trabecular bone, which responds throughout life to joint loading and orientation, offers a powerful way to investigate these differences [1,2]. Interpreting individual variation in fossil hominins, however, first requires establishing a meaningful baseline of intraspecific variation in extant taxa. When sampling non-human apes, researchers are careful to include only wild-origin, non-pathological individuals, since captivity can significantly alter behavior – and by extension, internal bone structure. Yet this level of scrutiny is often absent when assembling comparative human samples. Many modern skeletal collections are composed of individuals from post-industrial contexts, often of advanced age or with compromised health, whose lifestyles and mobility patterns differ dramatically from those of past populations [3]. Given these differences, habitually shod, post-industrial modern humans may not be the best reference point for interpreting bipedalism in early hominins.

Here, we investigated changes in trabecular bone structure in the tarsals of the medial column of the foot between shod and unshod modern humans (*Homo sapiens*). Using high-resolution microtomographic scans, the complete trabecular network was analyzed in the talus, navicular, and medial cuneiform of 40 shod and 16 unshod modern humans. Using canonical holistic morphometric analysis (cHMA) [4], average morphometric maps of bone volume fraction (BV/TV) and a scaled relative BV/TV (rBV/TV) were generated for each group and statistically compared.

Results from all three elements indicate significant differences between shod and unshod individuals, underscoring how even minor alterations in locomotor behaviors can lead to significant variations in trabecular bone structure. In the talus, shod individuals show higher rBV/TV posteriorly and medially across all subarticular regions, suggesting a more plantar-flexed and inverted ankle posture, while unshod individuals display higher rBV/TV laterally, suggesting a relatively more everted ankle posture.

In the navicular, shod individuals show higher rBV/TV in the subarticular region of the medial cuneiform facet, extending medially toward the tuberosity, while unshod individuals display higher rBV/TV beneath the intermediate cuneiform facet. This pattern suggests midfoot loading is more medially directed in shod individuals and more laterally directed in unshod individuals. At the facet for the talar head, shod individuals exhibit broader superior and medial concentrations of high rBV/TV and greater variance, whereas unshod individuals show a tighter superomedial concentration with lower variability, suggesting that footwear imposes distinct joint orientations.

In the medial cuneiform, group differences are subtler than in the talus or navicular, though unshod individuals show consistently higher rBV/TV. In the subarticular region for the first metatarsal, both groups show elevated rBV/TV in the superior half, with a slight medial skew in shod individuals, possibly reflecting kinematic differences at toe-off. Patterns under the navicular facet are nearly identical. On the plantar surface, both groups exhibit high rBV/TV at the tibialis posterior attachment, but only unshod individuals also show elevated values anterolaterally at the fibularis longus attachment, suggesting greater lateral stabilization.

These findings support recent experimental results [5] and demonstrate that even minor shifts in habitual loading – like those introduced by footwear – can meaningfully alter mechanical loading of the foot and impact the internal bone structure. This highlights the importance of careful contextualization of intraspecific variation with recent humans when inferring behavior from the internal bone structure fossil hominins.

For access to museum collections, we thank Rachel Ives (Natural History Museum, London), Rebecca George (Western Carolina University), Dawnic Steadman (University of Tennessee, Knoxville), Danny Westcott (Texas State University) and Deborah Cunningham (Texas State University). For their assistance with CT-scanning and data processing, we thank Bec Krolczyk (Texas State University) and Karley Spriggs (Indiana University Northwest). This research received support from the SYNTHESYS+ Project ([www.synthesys.info](http://www.synthesys.info)) which is financed by European Community Research Infrastructure Action under the H2020 Integrating Activities Programme, Project number 823827.

References: [1] Kivell, T.L., 2016. A review of trabecular bone functional adaptation: what have we learned from trabecular analyses in extant hominoids and what can we apply to fossils? *Journal of Anatomy*. 228, 569–594. [2] Ehrlich, P.J., Lanyon, L.E., 2002. Mechanical Strain and Bone Cell Function: A Review. *Osteoporosis International*. 13, 688–700. [3] Campanacho, V., Alves Cardoso, F., Ubelaker, D.H., 2021. Documented Skeletal Collections and Their Importance in Forensic Anthropology in the United States. *Forensic Sciences*. 1, 228–239. [4] Bachmann, S., Dunmore, C.J., Skinner, M.M., Pahr, D.H., Synek, A., 2022. A computational framework for canonical holistic morphometric analysis of trabecular bone. *Scientific Reports*. 12. [5] Apolito, Z.M., Palmisano, K.G., Holowka, N.B., 2025. The adaptive function of the human ankle joint complex during walking on uneven terrains with implications for hominin locomotion. *Journal of Human Evolution*. 203, 103678.

Poster Presentation Number 48, Session 1, Thursday 14:00 - 15:30

## Ergonomic constraints and anatomical variation in early stone tool behaviour: insights from the PaleoErgo project

Annapaola Fedato<sup>1</sup>

1 - McDonald Institute for Archaeological Research – University of Cambridge

The importance of anatomy–tool interactions is well established in ergonomic and engineering literature, where optimal tool design is closely linked to user morphology [1]. A growing body of archaeological research has similarly shown that biometric variation in the hand—such as grip strength, morphology, and manual dimensions—can significantly influence the efficiency and muscular demands associated with Lower Palaeolithic (LP) tool use [2,3]. Experimental studies have demonstrated that grip type and the number of digits engaged correlate strongly with tool size. Larger tools enable users to exert greater force by distributing pressure across a larger surface area, thereby increasing efficiency. Specific features—such as edge angle and the retention of cortex, particularly in handaxes—can also reduce discomfort during use. Some of these ergonomic properties recur in both early tools and later hafted technologies [3].

Anatomical variation further plays a critical role. Individuals with longer digits or larger hands experience reduced joint stress and achieve greater cutting efficiency [4]. As a result, hand morphology likely influenced both tool selection and performance, with biometric traits sometimes outweighing tool form in determining cutting success. This suggests that ergonomic constraints shaped not only behavioural decisions but also evolutionary pressures. Studies employing electromyography and pressure sensors confirm that both tool size and shape significantly affect muscle activation and perceived comfort. Larger tools elicit greater recruitment of upper and forearm muscles, facilitating increased cutting force but also raising overall muscular demand. However, this increased engagement often enables more secure and forceful grips, which can offset the higher load requirements [3]. Taken together, these findings suggest that ergonomic optimisation was a consistent selective pressure throughout the Palaeolithic, influencing both lithic design and the evolution of the hominin hand.

With the *PaleoErgo* project, we aim to investigate more deeply how anatomical variation and ergonomic factors shaped the production and use of LP tools. This is the first research of its kind to integrate experimental archaeology with magnetic resonance imaging, surface electromyography, motion capture, and occupational safety metrics to systematically evaluate ergonomic performance during both tool production and use. By placing muscles and bones at the centre of experimental archaeology, *PaleoErgo* offers a biomechanically explicit model for interpreting lithic technologies. It contributes new empirical data to test whether ergonomic optimisation played a role in the emergence, persistence, or abandonment of specific tool forms during human evolution. Crucially, *PaleoErgo* will allow us to identify which anatomical features most strongly contribute to the secure manipulation of stone cores during knapping, and to quantify the stresses involved in these behaviours. In doing so, the project provides direct empirical support for longstanding hypotheses linking upper limb evolution to the manual demands of tool production and use [5].

References: [1] Seo, N.J., Armstrong, T.J., 2008. Investigation of grip force, normal force, contact area, hand size, and handle size for cylindrical handles. *Human Factors: The Journal of the Human Factors and Ergonomics Society*. 50, 734–744. [2] Key, A.J.M., Lycett, S.J., 2016. Investigating interrelationships between Lower Palaeolithic stone tool effectiveness and tool user biometric variation: implications for technological and evolutionary changes. *Archaeological and Anthropological Sciences*. 10, 989–1006. [3] Key, A., Lycett, S.J., 2023. The ergonomics of stone tool use and production. In: Wynn, T., Overmann, K.A., Coolidge, F.L. (Eds.), *The Oxford Handbook of Cognitive Archaeology*. Oxford University Press, Oxford. [4] Rolian, C., Lieberman, D.E., Zermeno, J.P., 2011. Hand biomechanics during simulated stone tool use. *Journal of Human Evolution*. 61, 26–41. [5] Marzke, M.W., Shackley, M.S., 1986. Hominid hand use in the Pliocene and Pleistocene: evidence from experimental archaeology and comparative morphology. *Journal of Human Evolution*. 15, 439–460.

Poster Presentation Number 49, Session 1, Thursday 14:00 - 15:30

## Handaxe shaping without cultural models: implications for the origins of cumulative cultural evolution of know-how

Nolan Ferar<sup>1</sup>, Elena T. Moos<sup>2</sup>, William D. Snyder<sup>3</sup>, Maria Bolzmann<sup>4</sup>, Emil Sailer<sup>5</sup>, Mark W. Moore<sup>6</sup>, Claudio Tennie<sup>3</sup>

1 - Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour, Universidade do Algarve, Faro, Portugal · 2 - Institute for Archaeological Sciences, University of Tübingen, Tübingen, Germany · 3 - Department of Geosciences, WG for Early Prehistory and Quaternary Ecology, University of Tübingen, Tübingen, Germany · 4 - No institutional affiliation, Tübingen, Germany · 5 - Wirtschafts- und Sozialwissenschaftliche Fakultät, University of Tübingen, Tübingen, Germany · 6 - Archaeology and Palaeoanthropology, University of New England, Armidale, Australia

In the animal kingdom, human culture is unique in its diversity and in its open-endedness across behavioral domains. Over generations, cultural evolution has produced traits of increasing complexity that no single individual could have invented on their own [1]. Our special type of culture depends, in turn, on special underlying capacities for cultural learning. In particular, the ability to directly transmit know-how (that is, the knowledge of how to do and make things) is one of key and necessary abilities that enables the evolved cultural products and behaviors that surround us today – from language, to computers, to conducting archaeological excavations. Such “know-how copying,” while ubiquitous in modern humans, is exceedingly rare among non-human great apes, suggesting that this capacity evolved in hominins. Triangulating when and how human culture began to rely on know-how copying represents a key question in human evolution.

Archaeological data play a central role in addressing this question, as lithic and bone artifacts provide our most direct window into millions of years of hominin cultural and cognitive evolution. Past know-how copying can be inferred when it can be shown that a particular know-how lies beyond individual reach. In such cases, the know-how's existence implies underlying cumulative cultural evolution. Acheulean handaxes first appear in eastern Africa c. 1.9-1.6 Mya, and were produced, with some variability, by multiple hominin species across three continents and for well over one million years. It has been claimed that the ability to shape Acheulean handaxes required – and is indicative of – know-how copying, for instance via imitation (e.g., [2]) and teaching (e.g., [3]). If true, handaxes would then mark the presence of know-how copying as early as 1.9-1.6 Mya.

We tested this claim using a novel experimental approach – the “puppet method.” Originally described in theory by Moore [4], this approach experimentally disentangles knapping know-how from shaping know-how. Knapping know-how refers to the ability to predictably remove individual flakes and involves perceptual-motor skills. Shaping know-how refers to the ability to strategically organize flake removals towards imposing an intended shape. In the experiment, modern human, knapping-naïve “puppeteers” were tasked with replicating a handaxe target shape by directing the flake removals of an expert “puppet” knapper. This design allowed us to test whether knapping-naïve individuals could demonstrate handaxe shaping know-how, when experimentally seeded with the knapping know-how of the puppet.

Two puppeteers were tested independently. Each was provided with a handaxe target shape unknown to the puppet, and tasked with replicating the target shape in basalt flake blanks and tabular pieces of flint by directing the puppet knapper. Three archaeologists specialized in lithic technology were enlisted as independent coders and classified the puppeteers' shaping attempts typologically. Two puppeteer handaxe shaping attempts were classified as handaxes in this analysis – in one case, unanimously by all three coders. Thus, the knapping-naïve puppeteers successfully produced handaxe shapes in the absence of shaping know-how models. These findings challenge the widespread assumption that the shaping Acheulean handaxes per se must have required cultural transmission via direct know-how copying. This conclusion supports recent calls for a theoretical reorientation in the search for the origins of this key social learning capacity in our lineage [5].

We thank Gregor Bader and Alexander Janas for their assistance printing the target forms. We are grateful to David Boysen, Berrin Cep and Radu Iovita for offering their time and expertise as coders. We thank Viola Schmidt and Manuel Will for offering their perspective on the design of the handaxe target. We gratefully acknowledge the staff of the Theodor Stephan KG mine and the ENCI quarry for their kindness and generosity in providing us with the basalt and flint used in this study. These raw materials could not have been collected without the assistance of Jan Scheide and Gunther Moeller.

References: [1] Boyd, R., Richerson, P.J., 1996. Why culture is common, but cultural evolution is rare. *Proceedings of the British Academy*, 88, 77-93. [2] Shipton, C., 2019. The evolution of social transmission in the Acheulean. In: Overmann, K.A., Coolidge, F.L. (Eds.), *Squeezing minds from stones: cognitive archaeology and the evolution of the human mind*. Oxford University Press, Oxford, pp. 332-354. [3] Gärdenfors, P., Högberg, A., 2017. The Archaeology of Teaching and the Evolution of *Homo docens*. *Current Anthropology*, 58, 188-208. [4] Moore, M.W., 2019. Flake-making and the “cognitive rubicon”: Insights from stone-knapping experiments. In: Overmann, K.A., Coolidge, F.L. (Eds.), *Squeezing minds from stones: cognitive archaeology and the evolution of the human mind*. Oxford University Press, Oxford, pp. 179-199. [5] Tennie, C., Premo, L.S., Braun, D.R., McPherron, S.P., 2017. Early stone tools and cultural transmission: resetting the null hypothesis. *Current Anthropology*, 58.

Poster Presentation Number 50, Session 1, Thursday 14:00 - 15:30

## Sexual dimorphism and population history in human coxal bones: a 3D geometric morphometric study

Carla Figus<sup>1</sup>, Kristian Carlson<sup>2,3</sup>, Eugenio Bortolini<sup>1</sup>, Vitale Sparacello<sup>4</sup>, Rita Sorrentino<sup>5</sup>, Maria Giovanna Belcastro<sup>5</sup>, Jean-Jacques Hublin<sup>6</sup>, Markus Bastir<sup>7</sup>, Tim Ryan<sup>8</sup>, Stefano Benazzi<sup>1</sup>

1 - Department of Cultural Heritage, University of Bologna, Ravenna, Italy · 2 - Division of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, Los Angeles, USA · 3 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, WITS, South Africa · 4 - Department of Life and Environmental Sciences, University of Cagliari, Cittadella Monserrato, Cagliari, Italy · 5 - Department of Biological, Geological and Environmental Sciences, University of Bologna, Bologna, Italy · 6 - Collège de France, Paris, France · 7 - Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain · 8 - Department of Anthropology, The Pennsylvania State University, State College, PA, USA

The coxal bones (os coxae) represent critical skeletal elements that have undergone significant evolutionary modifications in response to the combined pressures of bipedal locomotion and obstetric demands [1]. Previous research has demonstrated their value in investigating sex differences and population-level variation. It has increasingly incorporated three-dimensional approaches to explore morphological diversity across modern and past human groups [2]. Building on these foundations, the present study aims to expand comparative analyses by integrating a broad range of diachronic, geographic, and biological contexts.

Our sample consists of 73 adult individuals representing modern European (Bologna, n=21) [3] and North American (North Carolina, n=13, New Mexico, n=33) populations, supplemented with five Upper Palaeolithic individuals from Arene Candide [4] and one individual from Dolní Věstonice [5]. The coxal bones were categorized by biological sex (male/female) and ancestry (European, North American White, Hispanic), with Native American individuals included for comparative analysis. We acquired high-resolution 3D models through CT scanning, followed by (semi)landmark-based geometric morphometric analysis employing Procrustes superimposition and Principal Component Analysis (PCA). Statistical evaluations included PERMANOVA for group differences, correlation analysis between shape variables and centroid size, and Canonical Variate Analysis (CVA) for classification accuracy.

Results reveal pronounced and statistically significant sexual dimorphism in whole coxal bone morphology ( $p < 0.001$ ), with the first principal component (PC1) effectively separating males and females. PC1 showed a significant association with centroid size ( $r = 0.455$ ,  $p < 0.001$ ), confirming size-related dimorphism in overall bone structure. Population variation was evident but secondary to sexual dimorphism, except for the acetabular region, whose discriminatory power was stronger for geographic variability between European and North American samples than for sexual dimorphism.

Form space analysis highlighted stronger dimorphic patterns than shape space alone, underscoring the importance of size in pelvic variation. Perhaps most notably, Upper Palaeolithic Arene Candide specimens displayed remarkable morphological similarity to modern North American White males despite their temporal separation of approximately 20,000 years (Euclidean distance=0.0045). This finding suggests remarkable evolutionary stability in certain aspects of pelvic architecture, raising questions about selective pressures and developmental constraints.

Classification accuracy reached moderate levels for whole coxal bones (CVA=49.30%) but was substantially lower for isolated acetabulum analysis (CVA=33.80%). Female groups demonstrated more distinct population separation than males, potentially reflecting differential selective pressures related to obstetric requirements across populations.

These findings enhance our understanding of human pelvic evolution in relation to locomotion, reproduction, and population history. The unexpected morphological similarity between Palaeolithic and modern specimens challenges simple linear models of evolutionary change and suggests potential homoplasy in human pelvic architecture. Furthermore, the differential patterns of variation between sexes and across distinct pelvic regions provide methodological insights for paleoanthropological assessments of fossil hominin material. This preliminary study contributes to ongoing debates regarding the complex interplay between natural and sexual selection and developmental constraints in shaping the human pelvis across evolutionary time and geographic space.

This work is funded by the European Union Horizon Europe research and innovation program—Marie Skłodowska-Curie Actions, HORIZON-TMA-MSCA-PF-GF (grant agreement: n.101108385—RISEN) awarded to CF. This research utilized data from the Free Access Decedent Database, funded by the National Institute of Justice grant number 2016-DN-BX-0144. We thank the database managers for granting access to the research materials. Digital archives for North Carolina individuals and the Arene Candide Upper Palaeolithic materials were accessed through MorphoSource (www.MorphoSource.org, Duke University). In particular, we thank the Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Genova e le province di Imperia, La Spezia e Savona that provided access to these data originally appearing in Sparacello et al. (2018), funded by Marie-Curie European Union COFUND Durham Junior Research Fellowship [under EU grant agreement number 267209], and by the Wolfson Institute for Health and Wellbeing, Durham, UK. We thank the NCSU Forensic Analysis Lab and the MorphoSource repository for providing access to 3D scan data of modern human coxal bones from North Carolina, curated and digitized by Rebecca Cook and colleagues. Data was acquired using structured light scanning (Artec Spider) at the Laboratory of Chris Walker.

References: [1] Gruss, L.T., Schmitt, D., 2015. The evolution of the human pelvis: changing adaptations to bipedalism, obstetrics and thermoregulation. *Philosophical Transactions of the Royal Society B: Biological Sciences*. 370, 20140063. [2] Betti, L., 2017. Human variation in pelvic shape and the effects of climate and past population history. *The Anatomical Record*. 300, 687–697. [3] Belcastro,

- M.G., Bonfiglioli, B., Pedrosi, M.E., Zuppello, M., Tanganelli, V., Mariotti, V., 2017. The history and composition of the identified human skeletal collection of the Certosa Cemetery (Bologna, Italy, 19th–20th Century). *International Journal of Osteoarchaeology*, 27, 912–925. [4] Sparacello, V.S., Rossi, S., Pettitt, P., Roberts, C.A., Salvatore, J.R., Formicola, V., 2018. New insights on Final Epigravettian funerary behaviour at Arene Candide Cave (Western Liguria, Italy) from osteological and spatial analysis of secondary bone deposits. *Journal of Anthropological Sciences*, 96, 1–24. [5] Mitnik, A., Wang, C.-C., Svoboda, J., Krause, J., 2016. A molecular approach to the sexing of the triple burial at the Upper Palaeolithic site of Dolní Věstonice. *PLOS ONE*, 11, e0163019.

Poster Presentation Number 52, Session 1, Thursday 14:00 - 15:30

## From data-sparse to data-rich with *PyLithics*: analysis of lithics using computer vision algorithms

Robert A. Foley<sup>1</sup>, Jason J. Gellis<sup>1</sup>

1 - Leverhulme Centre of Human Evolution, Department of Archaeology, University of Cambridge, UK

For over two centuries, lithic artefacts have formed the cornerstone of archaeological insight into deep human history. Despite their abundance and interpretative richness, lithics remain under-quantified and analytically constrained. From early attempts to apply typologies [1] to more recent technological [2] and quantitative approaches [3], methods changed and advanced. Laborious manual measurements, qualitative classification schemes, and inconsistent documentation conventions have limited lithic analysis to a “small data” paradigm—fragmented, heterogeneous, and labour-intensive. By contrast, adjacent fields, such as genomics, have undergone transformative shifts through the adoption of big data and machine learning. Lithic archaeology, however, has lacked an analogous framework capable of leveraging computational scalability.

Here we introduce *PyLithics* [4], an open-source Python software package designed to operationalise big data and computer vision methods within lithic analysis. *PyLithics* directly addresses the three critical challenges to scaling archaeological science: the volume of lithic artefacts, the velocity of data acquisition, and the variety of lithic types—collectively known as the “3Vs” of big data. Central to its design is the automated extraction of high-dimensional quantitative data from 2D line drawings. This focus allows the software to leverage vast, underutilized historical archives. Scans of line drawings can be processed at a rate of 50 lithics per minute.

*PyLithics* employs a range of computer vision techniques—edge detection, contour mapping, arrow vector analysis, and shape quantification—to transform static illustrations into rich, structured datasets. Crucially, it automates the identification and quantification of key technological attributes, including surface identification, flake scar dimensions, scar orientation, and lithic symmetry. In addition to replicating standard lithic metrics, *PyLithics* generates novel analytical features such as Voronoi polygon distributions and Convex Hull parameters—providing quantitative access to aspects of lithic morphology that were previously difficult or impossible to measure manually.

In this paper, we present the conceptual foundations, methodological design, and examples of analytical results of *PyLithics* procedures. We apply the software to a range of datasets from sites in Africa, Western Asia and Europe. We first present examples of the richness of data that can be extracted by *PyLithics*, and then examine relationships between flake sizes and scar counts for different technologies and assemblages. Finally, we test two hypotheses – one, that quantitative scar patterns can be used to compare and distinguish assemblages and technologies, and two, that convex hull measurements of flakes can represent shape complexity and volumetric change across reduction sequences, providing a proxy for assessing lithic reduction intensity and technological choices.

These results illustrate both the immediate benefits and long-term research potential of a fully computational, data-rich approach to lithic analysis.

Funding from The Alan Turing Institute and the British Academy. We thank Camila Rangel-Smith and Marta Mirazón Lahr for advice and support.

References: [1] Bordes, F., de Sonneville-Bordes, D., 1970. The significance of variability in Palaeolithic assemblages. *World Archaeology*. 2, 61–73. [2] Boëda, E., 1995. Levallois: a volumetric construction, methods, a technique. In: Dibble, H.L., Bar-Yosef, O. (Eds.), *The Definition and Interpretation of Levallois Technology*. Prehistory Press, Madison, WI, pp. 41–68. [3] Muller, A., Shipton, C., Clarkson, C., 2022. Stone toolmaking difficulty and the evolution of hominin technological skills. *Scientific Reports*. 12. [4] Gellis, J., Smith, C., Foley, R., 2022. *PyLithics*: A Python package for stone tool analysis. *Journal of Open Source Software*. 7, 3738.

Poster Presentation Number 52, Session 1, Thursday 14:00 - 15:30

## Building an Sr-isotope baseline of Mozambique to reconstruct Stone Age human dispersals

Sarah Marie Foley<sup>1</sup>, Gina M. Buckley<sup>1</sup>, Hannah F. James<sup>2</sup>, May Murungi<sup>1</sup>, Judite Nhanombe<sup>1</sup>, Elena Skosey-LaLonde<sup>1,3</sup>, Christophe Snoeck<sup>2</sup>, Nuno Bicho<sup>1</sup>

1 - ICArEHB, FCHS, Universidade do Algarve, Campus de Gambelas, Faro, Portugal · 2 - Archaeology, Environmental Changes & Geo-Chemistry, Vrije Universiteit Brussel, Brussels, Belgium · 3 - Department of Anthropology, University of Connecticut, Storrs, Connecticut, USA

Recently, there has been a concerted effort to investigate Stone Age sites within Mozambique to identify how modern *Homo sapiens* may have migrated from Southern to East Africa during key dispersal events. Strontium (<sup>87</sup>Sr/<sup>86</sup>Sr) isotope analysis has become a crucial method for detecting prehistoric human mobility over the landscape. Although recent work has produced an <sup>87</sup>Sr/<sup>86</sup>Sr isoscape for all of sub-Saharan Africa [1], regional studies throughout the continent have been sparse. Additionally, the preservation of hominin remains in this region is poor due to environmental factors, and researchers must turn to zooarchaeology to understand hominin mobility and behavior during the Pleistocene. To tackle these issues, we present the initial development of bioavailable <sup>87</sup>Sr/<sup>86</sup>Sr baselines for the Save and Limpopo River basins in Mozambique from plants and faunal remains. The underlying geology of a region yields specific <sup>87</sup>Sr/<sup>86</sup>Sr isotopic compositions depending on a variety of geologic and geographic factors including bedrock weathering and atmospheric input [2]. Plants take up Sr from the soil through their roots. Bioavailable Sr-signatures are then reflected in the local fauna consuming these plants. Therefore, the landscape and underlying geology of a region are fundamental components of reconstructing hominin mobility and behavior. Determining local Sr-baselines is essential as human movements on the landscape have implications for subsistence, access to water, and sourcing raw materials used for artifact production.

To develop a bioavailable <sup>87</sup>Sr/<sup>86</sup>Sr isoscape, plants of differing root lengths (grasses, shrubs, and trees) were systematically collected at survey locations to capture the fluctuating geology and isotopic values throughout the region. A total of 41 plant samples and two modern faunal tooth enamel samples were analyzed for <sup>87</sup>Sr/<sup>86</sup>Sr isotope analysis at the Brussels Bioarchaeology lab, at the Vrije Universiteit Brussel. Results indicate that there is a wide range of <sup>87</sup>Sr/<sup>86</sup>Sr values for the region surveyed: 0.70988 to 0.7352. These results support the need for more regional baseline development in Africa, specifically Mozambique, a traditionally understudied area in a broader archaeological context.

The isoscape of Mozambique will be modeled in two ways: kriging and machine learning (ML). Kriging and ML are complementary methods for building isoscapes, and using both will strengthen the results. Kriging is a geostatistical technique that predicts values based on spatial autocorrelation, providing transparent interpolation and built-in uncertainty estimates. Machine learning methods like Random Forest Regression, by contrast, model complex, non-linear relationships between isotope values and environmental variables without assuming simple spatial structure. Applying both approaches will allow us to compare predictive models, capture both spatial patterns and environmental drivers of variation, and build a more accurate and resilient isoscape for Mozambique.

This research is ongoing, and samples will continue to be collected during the upcoming field seasons as the ERC-DISPERSALS team will be exploring new areas of Mozambique not covered in the prior seasons in an effort to capture a more comprehensive bioavailable <sup>87</sup>Sr/<sup>86</sup>Sr isoscape. These areas include Inhassoro, near the coast, Colouche Caves in Inhambane, and Massingir, closer to the South African border. This research, conducted through the ERC-DISPERSALS project, provides a foundation for future studies of human mobility, subsistence strategies, and sourcing raw materials for stone tools in this understudied region. Furthermore, it contributes to global efforts aimed at producing maps of <sup>87</sup>Sr/<sup>86</sup>Sr isotope variability.

We would like to thank the Ministério da Agricultura, Direcção Nacional do Património Cultural, and the Universidade Eduardo Mondlane, in Maputo for their support and collaboration during our successful fieldwork in Mozambique. This work was funded by the DISPERSALS project (101052761-DISPERSALS-ERC-2021-ADG) with funding provided by the European Research Council awarded to Nuno Bicho. Thank you to Christophe Snoeck and Hannah James and the Brussels Bioarchaeology lab for invaluable support with lab training and analyses. Lastly, thank you to the paleo-ecology survey team for the extraordinary efforts that went into organizing and carrying out the field surveys, and changing many tires.

References: [1] Wang, X., Bocksteger, G., Arandjelovic, M., Agbor, A., Anedakin, S., Aubert, F., Ayimisin, E.A., Bailey, E., Barubiyo, D., Bessone, M., Bobe, R., Bonnet, M., Boucher, R., Brazzola, G., Brewer, S., Lee, K.C., Carvalho, S., Chancellor, R., Cipoletta, C., Cohen, H., Copeland, S.R., Corogenes, K., Costa, A.M., Coupland, C., Curran, B., de Ruiter, D.J., Deschner, T., Dieguez, P., Dierks, K., Dilambaka, E., Dowd, D., Dunn, A., Egbe, V.E., Finckh, M., Fruth, B., Gijanto, L., Yuh, Y.G., Goedmakers, A., Gokec, C., Gomes Coelho, R., Goodman, A.H., Granjon, A.-C., Grimes, V., Grueter, C.C., Haour, A., Hedwig, D., Hermans, V., Hernandez-Aguilar, R.A., Hohmann, G., Imong, I., Jeffery, K.J., Jones, S., Junker, J., Kadam, P., Kambere, M., Kambi, M., Kienast, I., Knudson, K.J., Langergraber, K.E., Lapeyre, V., Lapuente, J., Larson, B., Lautenschläger, T., le Roux, P., Leinert, V., Llana, M., Logan, A., Lowry, B., Lüdecke, T., Maretti, G., Marrocoli, S., Fernandez, R., McNeill, P.J., Meier, A.C., Meller, P., Monroe, J.C., Morgan, D., Mulindahabi, F., Murai, M., Neil, E., Nicholl, S., Niyigaba, P., Normand, E., Ormsby, L.J., Diotot, O., Pacheco, L., Piel, A., Preece, J., Regnaud, S., Richard, F.G., Richards, M.P., Rundus, A., Sanz, C., Sommer, V., Sponheimer, M., Steele, T.E., Stewart, F.A., Tagg, N., Tédonzong, L.R., Tickle, A., Toubga, L., van Schijndel, J., Vergnes, V., Njomen, N.W., Wessling, E.G., Willie, J., Wittig, R.M., Yurkiw, K., Zipkin, A.M., Zuberbühler, K., Kühl, H.S., Boesch, C., Oelze, V.M., 2024. Strontium isoscape of sub-Saharan Africa allows tracing origins of victims of the transatlantic slave trade. *Nature Communications*. 15. [2] Capo, R.C., Stewart, B.W., Chadwick, O.A., 1998. Strontium isotopes as tracers of ecosystem processes: theory and methods. *Geoderma*. 82, 197–225.

Charoula M. Fotiadou<sup>1,2</sup>, Jesper Borre Pedersen<sup>3</sup>, H  l  ne Rougier<sup>4</sup>, Mirjana Roksandic<sup>5</sup>, Andrew W. Kandel<sup>3</sup>, Miriam N. Haidle<sup>3</sup>, Nicholas J. Conard<sup>6</sup>, Kathrin N  gele<sup>7</sup>, Maria Spyrou<sup>1</sup>, Johannes Krause<sup>7</sup>, Patrick Semal<sup>8</sup>, Du  an Mihailovi  <sup>9</sup>, Isabelle Crevecoeur<sup>10</sup>, Cosimo Posth<sup>1,2,7</sup>

Knowledge of the demographic history of Neanderthals remains incomplete, including the population processes that preceded their disappearance. In Europe, evidence of some level of genetic continuity has been found from at least 120,000 years ago despite multiple subsequent population radiations [1,2]. While it has been proposed that a genetic turnover gave rise to European Late Neanderthals (~60,000–40,000 years before present) [3], the timing and geographic location of this event are currently unknown. In this study, we generated six new Neanderthal mitochondrial genomes (mtDNA) of individuals retrieved from four archaeological sites in France, Belgium, and Serbia, and analyzed them alongside a comprehensive dataset of 49 published Neanderthal mtDNA sequences. We integrated phylogenetic and Bayesian molecular dating methods with archaeological data to reconstruct temporal and spatial patterns in Neanderthal distribution. Our phylogenetic results show that nearly all Late Neanderthal individuals across Europe fall within a single, recently diversified mtDNA lineage, suggesting a strong population bottleneck followed by rapid expansion. We molecularly estimate the timing of this diversification event to ~65,000 years ago, and propose it likely originated from a population refugium in southwestern Europe. The analysis of the extensive archaeological data contained in the ROAD database confirms a significant contraction in the distribution of Neanderthal sites during MIS 4 towards southwestern France. This is followed by a wider geographic spread, which is consistent with a post-bottleneck population re-expansion across Europe. In addition, Bayesian Skyline analyses indicate a sharp decline in the maternal effective population size beginning ~46,000 years ago and reaching a minimum ~41,000 years ago, shortly before the Neanderthal extinction. The integration of genetic and archaeological datasets offers a more detailed understanding of Late Neanderthal population history and reveals the role of climate-driven refugia and subsequent range expansions in shaping the genetic landscape of Neanderthals through time.

References: [1] Peyrégne, S., Slon, V., Mafessoni, C., de Filippo, C., Hajdinjak, M., Nagel, S., Nickel, B., Essel, E., Le Cabec, A., Wehrberger, K., Conard, N.J., Kind, C.J., Posth, C., Krause, J., Abrams, G., Bonicand, D., Di Modica, K., Tostain, M., Kelso, J., Meyer, M., Pääbo, S., Prüfer, K., 2019. Nuclear DNA from two early Neanderthals reveals 80,000 years of genetic continuity in Europe. *Science Advances*. 5 [2] Vernot, B., Zavalza, E.I., Gómez-Olivencia, A., Jacobs, Z., Slon, V., Mafessoni, C., Romagné, F., Pearson, A., Petr, M., Sala, N., Pablos, A., Aranburu, A., de Castro, J.M.B., Cardonell, E., Li, B., Krajačič, M.T., Krivoslavskii, A.I., Kolobova, K.A., Kozlikin, M.B., Shunkov, M.V., Derevianko, A.P., Viola, B., Grote, S., Essel, E., Herráiz, D.L., Nagel, S., Nickel, B., Richter, J., Schmidt, A., Petr, B., Kelso, J., Roberts, R.G., Arsuaga, J.-L., Meyer, M., 2021. Unearthing Neanderthal population history using nuclear and mitochondrial DNA from cave sediments. *Science*. 372 [3] Hajdinjak, M., Fu, Q., Hübner, A., Petr, M., Mafessoni, F., Grote, S., Skoglund, P., Narasimhan, V., Rougier, H., Grevcoeur, I., Semal, P., Soressi, M., Talamo, S., Hublin, J.-J., Guisá, I., Kučan, Z., Rudan, P., Golovanova, L.V., Doronichev, V.B., Posth, C., Krause, J., Korlević, P., Nagel, S., Nickel, B., Slatkin, M., Patterson, N., Reich, D., Prüfer, K., Meyer, M., Pääbo, S., Kelso, J., 2018. Reconstructing the genetic history of late Neanderthals. *Nature*. 555, 652–656.

Poster Presentation Number 53, Session 1, Thursday 14:00 - 15:30

## Comparative mandibular growth in Neanderthals and *Homo sapiens*: insights from periosteal bone modeling and geometric morphometrics

Sarah E. Freidline<sup>1,2</sup>, Jean-Jacques Hublin<sup>2,3</sup>, Bruno Maureille<sup>4</sup>, Alexandra Schuh<sup>2</sup>

1 - Department of Anthropology, University of Central Florida, Orlando, FL, USA · 2 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 3 - Chaire Paléoanthropologie, CIRB (UMR 7241–U1050), Collège de France, Paris, France · 4 - UMR5199 PACEA: de la Préhistoire à l'Actuel: Culture, Environnement et anthropologie Université de Bordeaux, Pessac cedex, France

Neanderthals exhibit distinctive mandibular morphology relative to *Homo sapiens*, most notably lacking a chin, the presence of a retromolar space, and displaying differences in ramus shape. Geometric morphometric studies have shown that such taxon-specific features arise early in ontogeny [1-2], and prior research has identified unique bone modeling patterns—defined by the distribution of bone formation and resorption—in Neanderthals [3-4]. However, bone modeling in pre-adolescent Neanderthals and fossil *H. sapiens*, who typically possess more robust mandibles than recent humans, remains poorly understood.

This study examines mandibular bone modeling patterns in juvenile Neanderthals (n=6) and Late Pleistocene fossil (n=5) and recent *H. sapiens* (n=30), spanning neonatal to adolescent age groups defined by dental eruption stages. Bone modeling data were acquired directly from fossils using a Nanofocus confocal microscope or indirectly from epoxy replicas analyzed with a digital microscope. Patterns of bone formation and resorption were quantified and visualized through digital mapping projected onto three-dimensional surface models. Geometric morphometric and multivariate statistical analyses were conducted in parallel to assess ontogenetic trajectories.

Results reveal that both fossil and recent *H. sapiens* show progressive development of the chin throughout ontogeny, consistent with prior findings that the mental eminence begins forming before the eruption of the first permanent molar [5-6]. This feature develops via bone deposition along the inferior symphysis and resorption near the incisal roots, producing a projecting bony shelf—most prominent by adolescence.

In Neanderthals, symphyseal bone modeling is more variable and generally characterized by more extensive bone formation compared to modern humans. Both fossil *H. sapiens* and Neanderthals exhibit substantial resorption along the body of the corpus and mandibular ramus, particularly within the masseteric fossa, across all ontogenetic stages. This pattern, consistent with previous studies on Neanderthals [4], differs from that of other primates, and may reflect greater anterior facial growth and lateral growth associated with larger faces and broader mandibles, respectively. Overall, this integrative approach highlights the developmental coordination between mandibular and facial growth, suggesting that the human ontogenetic trajectory is structured to support a retracted facial profile from early life onward.

We would like to thank J.-L. Kahn (University of Strasbourg, France); G. Abrams and D. Bonjean (Seladina Cave Archaeological Centre, Belgium); A. Balzeau (Musée de l'Homme, France); J.-J. Cleyet-Merle (Musée National de Préhistoire, France); Hila May, Israel Hershkovitz, and Yoel Rak (Tel-Aviv University, Israel); C. Stringer and R. Krusynski (Natural History Museum, London); A. Oujaa, A. Ben-Ncer, and M.A. El Hajraoui (Institut National des Sciences de l'Archéologie et du Patrimoine, Morocco).

References: [1] Terhune, C.E., Ritzman, T.B., Robinson, C.A., 2018. Mandibular ramus shape variation and ontogeny in *Homo sapiens* and *Homo neanderthalensis*. *Journal of Human Evolution*. 121, 55-71. [2] Ponce de León, M.S., Zollikofer, C.P., 2001. Neanderthal cranial ontogeny and its implications for late hominid diversity. *Nature*. 412, 534-8. [3] Rosas, A., Martínez-Maza, C., 2010. Bone remodeling of the *Homo heidelbergensis* mandible: the Atapuerca-SH sample. *Journal of Human Evolution*. 58, 127-37. [4] Martínez-Maza, C., Rosas, A., García-Vargas, S., Estalrich, A., de la Rasilla, M., 2011. Bone remodelling in Neanderthal mandibles from the El Sidrón site (Asturias, Spain). *Biology Letters*. 7, 593-6. [5] Coquerelle, M., Bookstein, F.L., Braga, J., Halazonetis, D.J., Weber, G.W., Mitteroecker, P., 2011. Sexual dimorphism of the human mandible and its association with dental development. *American Journal of Physical Anthropology*. 145, 192-202.

Poster Presentation Number 54, Session 1, Thursday 14:00 - 15:30

## Diaphyseal geometry and cortical bone distribution of *H. naledi* femora from the Lesedi Chamber of the Rising Star cave, South Africa

Lukas Friedl<sup>1,2</sup>, Andrea Lukova<sup>1,3</sup>, Damiano Marchi<sup>4,5</sup>, Steven Churchill<sup>6,5</sup>, Jeremy DeSilva<sup>7,5</sup>, John Hawks<sup>8,5</sup>, Lee Berger<sup>5</sup>

1 - Department of Anthropology, University of West Bohemia in Pilsen, Pilsen, Czech Republic · 2 - Interdisciplinary Center for Archaeology and Evolution of Human Behavior, Universidade do Algarve, Faro, Portugal · 3 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 4 - Department of Biology, University of Pisa, Pisa, Italy · 5 - Evolutionary Studies Institute and Centre for Excellence in PalaeoSciences, University of the Witwatersrand, Johannesburg, South Africa · 6 - Department of Evolutionary Anthropology, Duke University, North Carolina, USA · 7 - Department of Anthropology, Dartmouth College, New Hampshire, USA · 8 - Department of Anthropology, University of Wisconsin, Wisconsin, USA

Femoral specimens of *Homo naledi* from the Dinaledi Chamber of the Rising Star cave complex in South Africa have been previously described as possessing a mosaic combination of ancestral, derived, and unique characteristics in their external [1], as well as in their internal morphology [2]. Femoral specimens of *H. naledi* discovered in the Lesedi Chamber of the Rising Star cave have confirmed the range of variation in the species and informed on some new morphologies, undocumented in the Dinaledi sample [3]. Here, we present further characterization of the Lesedi sample through diaphyseal cross-sectional analysis of the femoral specimens U.W. 102a-001, U.W. 102a-003, and U.W. 102a-004 using microCT images. The latter two specimens represent proximal and distal segments of a single individual. Midshaft (in U.W. 102a-003) and subtrochanteric (in U.W. 102a-001 and U.W. 102a-003) sections were analyzed. The midshaft area of the U.W. 102a-003 and 004 is damaged and as a result, the section that was analyzed was taken a bit more proximally, at the level of fully preserved periosteal contour, which nonetheless still preserves midshaft cross-sectional characteristics. Subtrochanteric section is preserved and was analyzed in both individuals. Midshaft relative cortical area (%CA) in U.W. 102a-003 falls well within the distribution of the Dinaledi sample. The same applies for the midshaft diaphyseal shape ( $I_x/I_y$ , anteriorly elongated) and other unstandardized cross-sectional parameters. In fact, U.W. 102a-003 is very similar in its midshaft cross-sectional geometry to U.W. 101-003, one of the Dinaledi specimens internally described in [2]. At the subtrochanteric level, the relative cortical area is also well within the variation of the Dinaledi sample. Median shape index ( $I_{max}/I_{min}$ ) values are almost identical between Lesedi and Dinaledi samples with medio-laterally elongated shafts. Overall, the Lesedi femora are internally almost identical to the Dinaledi sample and even the external dimensions are very similar. Given that both Lesedi specimens are incomplete and partially lack reliable indicators of body size (either bone length or femoral head), we can safely assume that cross-sectional parameters are comparable between Dinaledi and Lesedi samples. The internal, cross-sectional morphology of the Lesedi femora further supports functional and phylogenetic interpretations based on comparisons with other fossil hominins, recent humans, and apes published in our previous work [2].

We thank the National Geographic Society and the National Research Foundation of South Africa for significantly funding the recovery and study of the remains from Rising Star. LF and AL have been supported by the Czech Science Foundation (grant number 25-16018S). The authors wish to thank those who facilitated the data collection: namely Bernhard Zipfel and Gideon Chinamira at the Evolutionary Studies Institute.

References: [1] Friedl L, Claxton AG, Walker CS, Churchill SE, Holliday TW, Hawks J, Berger LR, DeSilva JM, Marchi D. Femoral neck and shaft structure in *Homo naledi* from the Dinaledi Chamber (Rising Star System, South Africa). *J Hum Evol*. 2019 Aug;133:61-77. doi: 10.1016/j.jhevol.2019.06.002. [2] Marchi D, Walker CS, Wei P, Holliday TW, Churchill SE, Berger LR, DeSilva JM. The thigh and leg of *Homo naledi*. *J Hum Evol*. 2017 Mar;104:174-204. doi: 10.1016/j.jhevol.2016.09.005. [3] Walker CS, Cofran ZD, Grabowski M, Marchi D, Cook RW, Churchill SE, Tommy KA, Throckmorton Z, Ross AH, Hawks J, Yapuncich GS, Van Arsdale AP, Rentzeperis FI, Berger LR, DeSilva JM. Morphology of the *Homo naledi* femora from Lesedi. *Am J Phys Anthropol*. 2019 Sep;170(1):5-23. doi: 10.1002/ajpa.23877.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## The posterior vault shape in *Homo* – Assessing XJY6 and XUC1 morphometric affinities

Martin Friess<sup>1</sup>, Xiujie Wu<sup>2</sup>

1 - Ecoanthropologie; UMR 7206, Museum National d'Histoire Naturelle, Paris Université, France · 2 - Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

The fossil record of China exhibits a remarkable diversity among middle Pleistocene hominins, thus adding to ongoing debate on their taxonomy and phylogenetic relationships. Here, we further assessed this diversity by focusing on craniometric affinities of Xujiayao (XJY6) and Xuchang 1 (XUC1) with a representative sample of fossils of the genus *Homo*. We conducted a geometric morphometric analysis of the posterior vault of a total of 56 specimens, operationally assigned to four different species of *Homo*, *H. sapiens* (H.s.), *H. neanderthalensis* (H.n.), *H. heidelbergensis* (H.h.), and *H. erectus s.l.* (H.e.). A total of 289 standard and semilandmarks were collected from surface models on the parietal, temporal and occipital squama using landmark editor [1]. We additionally used a landmark set of the parietal portion only, consisting of 153 standard and semilandmarks. Missing landmarks were estimated using Thin-plate spline warping of species-specific reference configurations to incomplete ones [2], and all four for XJY6 and XUC1, because of taxonomic uncertainty. Procrustes residuals of slid and symmetrized landmark configurations were submitted to a standard Principal Components Analysis (PCA). Pairwise Procrustes between-group distances were computed, and their significance was assessed using a permutation test. All computations were performed in R using dedicated libraries [3-5]. XJY6 and XUC1 fell largely outside the range of other groups. While the choice of reference did lead to minor shape variations among the estimated configurations, it did not affect the overall affinities of both specimens, as all variants clustered together. Key features driving the relative positions of both XJY6 and XUC1 were the very low, broad and posteriorly projecting vault, a very low maximum biparietal breadth, and relatively short and low temporal squama, common in H.e. Significance levels of pairwise distances suggest that H.e. vault and parietal shapes are different from other groups, as are those of H.s. Pairwise distances between H.h. and H.n. vault shape were not significantly different, though the parietal distances were. Based on pairwise distances to species means the two fossils XJY6 and XUC1 are first and foremost more similar to each other than to any other group. Their affinities with other hominins varied depending on which portion of the fossils are considered: The posterior vault morphology placed XJY6 relatively closer to H.e. than to other taxa, while XUC1 was relatively closer to H.n./H.h., these two groups being statistically inseparable. When only the parietal shape was considered, both appeared close to H.e. but also showed a relative proximity to Neandertals. While our results confirm previous findings and emphasize the distant position of both XJY6 and XUC1 relative to commonly recognized species of middle Pleistocene *Homo*, they illustrate the mosaic evolution of some shape features used in taxonomic assessments, and further document the diversity of middle Pleistocene hominins.

### References:

[1] Wiley, D.F., 2005. Landmark v 3.0. Institute for Data Analysis and Visualization, University of California. Davis. [2] Gunz, P., Mitteroecker, P., Neubauer, S., Weber, G.W., Bookstein, F.L., 2009. Principles for the virtual reconstruction of hominid crania. *Journal of Human Evolution*. 57, 48–62. [3] Dryden, I.L., 2023. Shapes package. R Foundation for Statistical Computing, Vienna, Austria. Contributed package. Version 1.2.6. <http://www.R-project.org>. [4] Schlager, S., 2017. Morpho and Rvcg – Shape Analysis in R., In: Zheng, G., Li, S. Szekeley, G. (Eds.), *Statistical Shape and Deformation Analysis*, Academic Press, p. 217–256. [5] Adams, D., Collyer, M., Kaliontzopoulou, A., Baken, E. 2025. "Geomorph: Software for geometric morphometric analyses. R package version 4.0.10. <https://cran.r-project.org/package=geomorph>.

Poster Presentation Number 55, Session 1, Thursday 14:00 - 15:30

## Endocasts and brain in paleoanthropology: a comparative volumetric and geometric morphometric analysis

Riccardo Frittitta<sup>1</sup>, Antonio Profico<sup>2</sup>, Julie Arnaud<sup>1,3</sup>

1 - Prehistoric and Anthropological Sciences, Department of Humanities, University of Ferrara, Ferrara, Italy · 2 - Department of Biology, University of Pisa, Pisa, Italy · 3 - UMR 7194, HNHP, National Museum of Natural History, Paris, France

The present study explores the substantial relationship between endocasts and brain morphology, a subject of ongoing significance within the disciplines of evolutionary anthropology and the broader field of paleoneurology [1]. A detailed comparative analysis of the brain and endocast in a sample of 37 living individuals is presented [2], employing a methodological framework integrating volumetric and geometric morphometric techniques to provide a comprehensive assessment.

The use of high-resolution magnetic resonance imaging (MRI) data facilitated the precise segmentation and extraction of brain structures, including the soft meningeal tissues (pia mater, arachnoid mater, and dura mater) that collectively form the brain hull. This methodological approach facilitates a more precise depiction of the brain's morphology. Concurrently, Computed Tomography (CT) scans were utilised to reconstruct endocasts in three dimensions, thereby capturing the imprint of the brain's outer surface on the inner cranial vault. For each individual, both brain and endocast were segmented using five distinct threshold values in order to evaluate the impact of this parameter on volumetric measurements [3].

In the interest of methodological validity and cross-validation of measurements, volumetric assessments were conducted using three distinct software packages and their associated tools. Geometric morphometric analyses, incorporating both manually placed anatomical landmarks, strategically positioned at key homologous points to capture major anatomical features, and automatically generated semilandmarks, providing a denser and more comprehensive coverage of the surface morphology, were performed to quantify and rigorously characterize shape variations. Furthermore, the implementation of linear regression analysis yielded a robust positive correlation between brain and endocast sizes, thereby signifying a substantial degree of correlation in overall size.

These analyses revealed significant variations in volume as a function of the threshold values employed during the segmentation process. It is noteworthy that endocast volumes exhibited a positive correlation with increasing threshold values, indicating that higher thresholds tend to include a greater volume of tissue in the reconstructed endocast. Conversely, brain volumes exhibited an inverse relationship, highlighting the differential sensitivity of these structures to the parameters of segmentation. Concerning the morphological differences, Principal Component Analysis (PCA) performed on landmarks and semilandmarks configurations delineated a degree of separation between the distribution of endocast and brain shapes within the multivariate morphospace, indicative of inherent morphological disparities that extend beyond merely size differences.

Collectively, these observations highlight the complexities and potential limitations of using endocasts as a reliable proxy for inferring detailed brain morphology in both extant and extinct species. The results of the study highlight the critical importance of meticulous consideration of methodological parameters in paleoanthropological and evolutionary research. Such consideration must include the selection of appropriate threshold values during image segmentation, the potential influence of intervening soft tissues and other structures between the brain and the endocranium, and the acknowledgement of individual variability in both the size and shape.

Reference: [1] Bruner, E., Beaudet, A., 2023. The brain of *Homo habilis*: Three decades of paleoneurology. *Journal of Human Evolution*. 174, 103281. [2] Fournier, M., Combès, B., Roberts, N., Braga, J., Prima, S., 2011. Mapping the distance between the brain and the inner surface of the skull and their global asymmetries. *Medical Imaging 2011: Image Processing*. 7962, 79620Y. [3] Balzeau, A., Mangin, J.-F., 2021. What are the synergies between paleoanthropology and brain imaging? *Symmetry*. 13, 1974.

Poster Presentation Number 56, Session 1, Thursday 14:00 - 15:30

## Dietary patterns of the oldest Neanderthals in Central Europe revealed with stable isotope ratio analysis

Benjamin T. Fuller<sup>1</sup>, Andrea Picin<sup>1</sup>, Laura Tassoni<sup>1</sup>, Jean-Jacques Hublin<sup>2,3</sup>, Adrian Marciszak<sup>4</sup>, Adam Nadachowski<sup>5</sup>, Wioletta Nowaczewska<sup>6</sup>, Paweł Socha<sup>7</sup>, Krzysztof Stefaniak<sup>4</sup>, Andrzej Wiśniewski<sup>8</sup>, Marcin Żarski<sup>9</sup>, Michael P. Richards<sup>10</sup>, Sahra Talamo<sup>1</sup>

1 - Department of Chemistry G. Ciamician, University of Bologna, Bologna, Italy · 2 - Collège of France, Paris, France · 3 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 4 - Department of Paleozoology, University of Wrocław, Wrocław, Poland · 5 - Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland · 6 - Department of Human Biology, University of Wrocław, Wrocław, Poland · 7 - Department of Evolutionary Biology and Ecology, Wrocław University, Wrocław, Poland · 8 - Department of Stone Age Archaeology, Institute of Archeology, University of Wrocław, Wrocław, Poland · 9 - Polish Geological Institute-National Research Institute, Warsaw, Poland · 10 - Department of Archaeology, Simon Fraser University, Burnaby, Canada

The reconstruction of Neanderthal dietary patterns with stable isotope ratio analysis is a topic of intense scientific research, debate and public interest for over the last 30 years (e.g., [1-3]). However, nearly all previous studies have focused on sites in western Europe or Asia and little isotopic research has been conducted in central or eastern Europe [1-3]. In order to improve our understanding and shed new light on this important topic, we present here an isotopic reconstruction of the subsistence practices of five early Neanderthal individuals (~116,000 to 94,000 years ago) from the site of Stajnia Cave in Poland. Stajnia Cave is an important natural rock shelter situated in southern Poland on the northern side of the Krakow-Częstochowa Upland (50° 36'58" N, 19°29'04" E) [4]. This site has been extensively excavated and has yielded a series of central and eastern European Micoquian lithics as well as a number of Neanderthal remains associated with a vast collection of Late Pleistocene steppe-tundra fauna species (e.g., reindeer, horse, bison, woolly rhinoceros/mammoth, bears, cave lions, hyenas, etc.) [4]. In addition, a series of Middle and Upper Paleolithic artifacts were recovered, including the oldest directly dated ivory pendant in Eurasia (41,500 years old) attributed to *Homo sapiens* [5].

Collagen was successfully extracted from the tooth roots of five Neanderthal individuals and was then analyzed for bulk carbon and nitrogen stable isotope ratios. These Neanderthal results were then compared with 80+ different faunal specimens, representing both herbivores and carnivores, which were recovered from the same site and layers as the Neanderthal teeth. In addition, 16 of these faunal specimens were directly <sup>14</sup>C dated [4-5] and 11 were found to be >50,000 <sup>14</sup>C years old, and thus likely to be directly comparable to these Neanderthals. Therefore, this research represents one of the largest and most detailed isotopic studies of Neanderthals and their potential prey species undertaken to date, and the first in Poland.

Findings indicate that these five Neanderthal individuals were functioning as top-level carnivores, in terms of protein consumption, with a direct focus on mammoth consumption. These results are in agreement with previous Neanderthal isotopic studies and reinforce the notion that Neanderthals had a relatively homogenous and conservative dietary pattern across both space and time, at least in terms of protein intake [1-3]. By providing the first high-resolution isotopic dataset for Neanderthals in Poland and one of the most detailed comparisons with local prey species in Central and Eastern Europe, this study significantly expands the geographic scope of our knowledge. It contributes to a more comprehensive understanding of Neanderthal subsistence strategies across their wider Eurasian range.

This research was funded by the Italian grant PRIN20209LLK8S\_001 DYNASTY: "Neanderthals dynamic pathway and resilience in central Europe through the chronometric sustainability" funded by the Ministry of University and Research (awarded to S. T.). A.P. has received funding from the Italian Ministry of University and Research - project FIS-2023-01196 POOL - Investigating cultural and biological scenarios of late Neanderthals and *Homo sapiens* in Poland.

References: [1] Bocherens, H., Fizet, M., Mariotti, A., Lange-Badré, B., Vandermeersch, B., Borel, J.P., Bellon, G., 1991. Isotopic biogeochemistry (<sup>13</sup>C,<sup>15</sup>N) of fossil vertebrate collagen: application to the study of a past food web including Neanderthal man. *Journal of Human Evolution*. 20, 481-492. [2] Richards, M.P., Trinkaus, E., 2009. Isotopic evidence for the diets of European Neanderthals and early modern humans. *Proceedings of the National Academy of Sciences, USA*. 106, 16034-16039. [3] Salazar-García, D.C., Power, R.C., Rudaya, N., Kolobova, K., Markin, S., Krivoschapkin, A., Henry, A.G., Richards, M.P., Viola, B., 2021. Dietary evidence from Central Asian Neanderthals: A combined isotope and plant microremains approach at Chagyrskaya Cave (Altai, Russia). *Journal of Human Evolution*. 156, 102985. [4] Picin, A., Hajdinjak, M., Nowaczewska, W., Benazzi, S., Urbanowski, M., Marciszak, A., Fewlass, H., Bosch, M.D., Socha, P., Stefaniak, K., Żarski, M., Wiśniewski, A., Hublin, J.-J., Nadachowski, A., Talamo, S., 2020. New perspectives on Neanderthal dispersal and turnover from Stajnia Cave (Poland). *Scientific Reports*. 10. [5] Talamo, S., Nowaczewska, W., Picin, A., Vazzana, A., Binkowski, M., Bosch, M.D., Cerratillo, S., Diakowski, M., Fewlass, H., Marciszak, A., Paleček, D., Richards, M.P., Ryder, C.M., Sinet-Mathiot, V., Smith, G.M., Socha, P., Sponheimer, M., Stefaniak, K., Welker, F., Winter, H., Wiśniewski, A., Żarski, M., Benazzi, S., Nadachowski, A., Hublin, J.-J., 2021. A 41,500 year-old decorated ivory pendant from Stajnia Cave (Poland). *Scientific Reports*. 11.

Podium Presentation, Session 4, Friday 08:30 – 10:30

## Exploring fire duration through bioapatite crystallite growth in Middle Paleolithic contexts

Giulia Gallo<sup>1,2</sup>

1- Collège de France, Chaire de Paléanthropologie /Paleoanthropology Chair, CIRB-Collège de France, CNRS /INSERM, Paris FR · 2- TRACES laboratory, Université Toulouse Jean Jaurès II, Toulouse FR

Fire provides light, heat, and the ability to modify resources and the environment. Contextualizing the use of fire is essential for interpreting site functions, occupation patterns, and broader social and economic aspects of hominin behavior. While evidence for fire is common in many Middle Paleolithic contexts, quantifying the duration of archaeological fire, potentially one of the most important variables, remains a challenge.

Here we offer a potential approach for estimating fire duration times with the average crystallite sizes of bioapatite in calcined bone, measured through high-resolution X-ray powder diffraction (HR-XRPD). Rietveld refinement is used to characterize the crystal structure, with the calculated diffraction pattern customized through data obtained with inductively coupled plasma mass spectrometry (ICP-MS). Experimental results from samples heated at 600, 800, and 1000°C demonstrate a correlation between crystallite growth and sustained exposure to high temperatures before bone mineral transformation to beta-tricalcium phosphate. This relationship may provide a proxy for assessing the length of time a fire was maintained at high heat, providing opportunities to test hypotheses of archaeological fire management, including fuel strategies, fire functionality, and site-use intensity.

Calcined bones from two well-known Neanderthal contexts in southwestern France, Roc de Marsal layer 9 (MIS 5) and Le Moustier levels A11–A13 (MIS 3), were also sampled and analyzed. Calcined bone from both sites exhibits patterns in crystallite sizes that can speak to differing fire durations. This data is explored in relation to each archaeological and depositional context, including revisited fire placements which resulted in stacked fire features at Roc de Marsal and as evidence of anthropogenic burning of megafauna at Le Moustier. Comparing the evidence from Roc de Marsal layer 9 and Le Moustier A11-A13 further contributes to our understanding of how Neanderthals used fire across contrasting climatic settings— including both in wooded temperate periods and in a drier, colder environment.

This study introduces the concept of fire duration as a potentially measurable variable in archaeological analysis. If validated further, calcined bone may serve as a quantitative, reproducible proxy for high-temperature fire exposure that can be sampled, compared, and interpreted. This approach underscores the importance of systematically recovering and studying burnt faunal remains found in the fine fraction of excavated materials, as fragile calcined bone offers valuable insights into hominin fire using behaviors previously unrecoverable.

I would like to thank the archaeological research teams of Le Moustier and Roc de Marsal, including Brad Gravina, Marc Thomas, Emmanuel Discamps, Vera Aldeias, Paul Goldberg, Shannon McPherron, Dennis Sandgathe, and Alain Turq for their support of this study and my larger research initiatives regarding fire technology through a zooarchaeological perspective on both faunal assemblages. Gratitude is also extended to Alexandra Navrotsky and Sergey Ushakov at the Navrotsky Eyring Center for Materials of the Universe (MotU) at Arizona State University along with Marigold Fyhrle for my initial training on diffraction methods, as well as Maxwell Terban at Momentum Transfer for HR-XRD instrumentation and advice. Finally, this study and the experiments supporting the archaeological interpretations could not have been possible without the assistance and patience of many members of the TRACES team at the Université Toulouse Jean Jaurès II including Alessandra Livraghi, Marine Gardeur, Luc Bordes, Julie Bachelier, and Jean-Marc Petillon. This project was funded by the Leakey Foundation.

Poster Presentation Number 57, Session 1, Thursday 14:00 - 15:30

## Tools and shifting grounds: lithic resource management during late Pleistocene in Western Iberia

Cristina Gameiro <sup>1</sup>Thierry Aubry <sup>1,2</sup>Henrique Matias <sup>1</sup>

1 - UNIARQ - Centre for Archaeology, School of Arts and Humanities, University of Lisbon, Lisboa, Portugal · 2 – Fundação Côa Parque, Vila Nova de Foz Côa, Portugal

Establishing a link between human technological adaptations and paleoclimatic changes during the Pleistocene-Holocene transition has been a persistent challenge in prehistoric archaeology. Deglaciation, sea-level rise, and climatic instability during the Late Pleistocene reshaped ecosystems and forced human societies to adapt. In western Iberia one major environmental change was the vegetation shift: deciduous oak (*Quercus*) expanded during warm phases, while pine species dominated in colder periods [1]. The rapid forest expansion influenced human mobility and site distribution. These climatic and ecological shifts directly affected human subsistence strategies. Faunal assemblages show a reduction in species diversity and increased reliance on small game like rabbits, fish, and birds [1]. At archaeological sites like Lapa dos Coelhos and Caldeirão, rabbit remains dominated Magdalenian levels, reaching over 90% [1]. Fish remains suggest seasonal use of sites, such as fishing during the spring at Lapa dos Coelhos [2].

Raw material use also reflects environmental and cultural adaptation. Distinct geographic areas exhibit heterogeneous archaeological record, however by comparing data across regions it is possible to identify regional variation on lithic technology. In Estremadura (central and coastal area), flint is locally available and dominates the assemblages. Comparisons with Côa and Vouga Valley sites, (inland areas without local flint or chert), show a decline in imported flint and an increased reliance on local materials from the Final Magdalenian onward [3]. This suggests reduced mobility and a shift toward the use of local lithic resources. Lithic technology changes, for example, tool miniaturization and increased microliths diversity became widespread during Final Magdalenian. The absence of systematic blade production, the use of cores-on-flake and hyaline quartz crystals for bladelet production or the systematic use of quartzite cobbles for expeditive flake production also demonstrate strategic responses to raw material constraints [1].

Using a new grid-based approach that combines morphometrical, technical, and functional analyses, we revisit existing data, comparing the identified cultural phases with climate changes, to present an updated synthesis of the lithic toolkits used by the last Pleistocene communities. In conclusion, the lithic resource management strategies during the Late Pleistocene in Western Iberia were shaped by both environmental pressures and cultural innovation.

References: [1] Gameiro, C., Aubry, T., Almeida, F., Dimuccio, L., Gabriel, S., Gaspar, R., Gomes, S., Valcarce, R.F., Figueiredo, S., Manzano, C., Marreiros, J., Oliveira, C., Santos, A.T., Silva, M.J., Tereso, J.P., Xavier, P., 2020. Archaeology of the Pleistocene-Holocene transition in Portugal: Synthesis and prospects. *Quaternary International*. 564, 113–137. [2] Roselló, E., Morales, A., 2010. Lapa dos Coelhos: informe sobre los restos de peces. In Mata Almonte, E. (Coord.) – Cuaternario y Arqueología: homenaje a Francisco Giles Pacheco, Cádiz, Asociación Profesional del Patrimonio Histórico-Arqueológico de Cádiz (ASPHA) / Servicio de Publicaciones de la Diputación Provincial de Cádiz. p. 159-167. [3] Aubry, T., Gameiro, C., Mangado Llach, J., Luís, L., Matias, H., Do Pereiro, T., 2016. Upper Palaeolithic lithic raw material sourcing in Central and Northern Portugal as an aid to reconstructing hunter-gatherer societies. *Journal of Lithic Studies*. 3, 7–28.

Poster Presentation Number 59, Session 1, Thursday 14:00 - 15:30

## Growth and developmental patterns in *Homo antecessor*: insights from postcranial remains from TD6 (Gran Dolina, Atapuerca)

Rebeca García-González<sup>1</sup>, Azahara Salazar-Fernández<sup>1</sup>, Julia Muñoz-Guarinos<sup>1</sup>, Laura Rodríguez<sup>1,2</sup>, Marta Fernández-Viejo<sup>1</sup>, Alba Navarro-Pérez<sup>1</sup>, Marta García-Barreiro<sup>1</sup>, Guillermo Zorrilla-Revilla<sup>1</sup>, Sonia Díaz-Navarro<sup>1</sup>, Nico Cirotto<sup>1</sup>, María Martín-Torres<sup>3</sup>, José Miguel Carretero<sup>1,4,5</sup>

1 - Laboratorio de Evolución Humana, Departamento de Historia, Geografía y Comunicación, Universidad de Burgos, Burgos, Spain · 2 - Área de Antropología, Universidad de León, León, Spain · 3 - Centro Nacional para el estudio de la Evolución Humana (CENIEH), Burgos, Spain · 4 - Centro UCM-ISCIH de Investigación sobre la Evolución y Comportamiento Humanos, Avda, Madrid, Spain · 5 - Unidad Asociada de I+D+i al CSIC Vidrio y Materiales del Patrimonio Cultural (VIMPAC), Madrid, Spain

In 1997, the new species *Homo antecessor* was defined based on fossils recovered from an archaeological test pit in the so-called Aurora stratum of the TD6 lithostratigraphic unit at the Gran Dolina Cave site in Burgos [1]. Since then, approximately sixty additional human fossils have been recovered from another small area of TD6, close to the original test pit excavated in the 1990s with an age range of 0.8-0.9 Ma [2]. The study of cranial, dental, and postcranial features observed in the TD6 fossils indicates that *H. antecessor* is characterized by a unique combination of primitive and derived traits within the genus *Homo*. The presence of derived traits suggests a phylogenetic relationship with the lineages of modern humans and Neanderthals [1]. This proposal has recently been supported by the analysis of dental proteomes, which provides evidence that *H. antecessor* is a close sister lineage to Middle and Late Pleistocene hominins, including modern humans, Neanderthals, and Denisovans [2].

In contrast to the wealth of anatomical and phylogenetic information, our direct knowledge of some paleobiological aspects of *H. antecessor* remains limited due to the scarcity of complete postcranial remains. This is particularly true for skeletal growth and development patterns. Previous studies on dental development have shown a relatively advanced third molar eruption along with generally reduced enamel formation times. Among the postcranial remains recovered at TD6, there are two complete clavicles [3], two partial humeri [4], and two complete scapulae [5]. In modern humans, body segments such as the humerus, scapula, and clavicle exhibit significant growth during the later phases of development. Therefore, examining the growth patterns of these three bones in *H. antecessor* provides a unique opportunity to investigate the skeletal development of this species.

We conducted a comparative analysis of linear and appositional growth by assessing bone length and cross-sectional properties from CT scans. Additionally, we evaluated maturational changes through 3D geometric morphometric analyses of bone shape. Our preliminary results reveal several differences in skeletal growth and development in *Homo antecessor* compared to modern humans, as well as its relationship to dental development. These findings will be discussed within the broader context of the evolution of modern human growth and developmental patterns.

The Atapuerca research project is financed by the Ministerio de Ciencia, Innovación y Universidades Grant PID2021-122355NB-C31 funded by MCIN/AEI/10.13039/501100011033 and "ERDF A way of making Europe".

Reference [1]: Bermúdez de Castro, J.M., Arsuaga, J.L., Carbonell, E., Rosas, A., Martínez, I., Mosquera, M., 1997. A Hominid from the Lower Pleistocene of Atapuerca, Spain: Possible Ancestor to Neandertals and Modern Humans. *Science*. 276, 1392–1395. [2] Welker, F., Ramos-Madrigal, J., Gutenbrunner, P., Mackie, M., Tiwary, S., Rakownikow, J., Chiva, C., Dickinson, M.R., Kuhlmann, M., de Manuel, M., Gelabert, P., Martín-Torres, M., Margvelashvili, A., Arsuaga, J.L., Carbonell, E., Marques-Bonet, T., Penkman, K., Sabido, E., Cox, J., Olsen, J.V., Lordkipanidze, D., Racimo, F., Lalueza-Fox, C., Bermúdez de Castro, J.M., Willerslev, E., Cappellini, E., 2020. The dental proteome of *Homo antecessor*. *Nature*. 580, 235–238. [3] Carretero, J.M., Lorenzo, C., Arsuaga, J.L., 1999. Axial and appendicular skeleton of *Homo antecessor*. *Journal of Human Evolution*. 37, 459–499. [4] Bermúdez de Castro, J.M., Carretero, J.M., García-González, R., Rodríguez-García, L., Martín-Torres, M., Rosell, J., Blasco, R., Martín-Francés, L., Modesto, M., Carbonell, E., 2012. Early pleistocene human humeri from the gran dolina-TD6 site (Sierra de Atapuerca, Spain). *American Journal of Physical Anthropology*. 147, 604–617. [5] García-Martínez, D., Green, D.J., Bermúdez de Castro, J.M., 2021. Evolutionary development of the *Homo antecessor* scapulae (Gran Dolina site, Atapuerca) suggests a modern-like development for Lower Pleistocene *Homo*. *Scientific Reports*. 11.

Podium Presentation, Session 6, Friday 16:00 – 17:40

## EDJ morphology of the Ruidera Middle Pleistocene molars (Castilla-La Mancha, Spain). Adding “muddle into the middle”?

Daniel García-Martínez<sup>1,2</sup>, Sara Díaz-Pérez<sup>3</sup>, Markus Bastir<sup>4</sup>, Clément Zanolli<sup>5</sup>, Katerina Harvati<sup>6,7,8</sup>, Carolin Roding<sup>6,7</sup>, Dimitris Kostopoulos<sup>9</sup>, Thomas Colard<sup>5,10</sup>, Tony Chevalier<sup>11,12,13</sup>, Antonio Rosas<sup>4</sup>, Carlos A. Palancar<sup>4</sup>

1 - Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 2 - Laboratory of Forensic Anthropology, Centre for Functional Ecology, Department of Life Sciences, Universidade de Coimbra, Coimbra, Portugal · 3 - Institute of Archaeology, University of Wrocław, Wrocław, Poland · 4 - Grupo de Paleoantropología, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (MNCN - CSIC) · 5 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France · 6 - Paleoanthropology, Senckenberg Centre for Human Evolution and Palaeoenvironment, Eberhard Karls University of Tübingen, Tübingen, Germany · 7 - Institute for Archaeological Sciences, Eberhard Karls University of Tübingen, Tübingen, Germany · 8 - DFG Centre of Advanced Studies ‘Words, Bones, Genes, Tools’, Eberhard Karls University of Tübingen, Tübingen, Germany · 9 - Museum of Geology - Palaeontology, School of Geology, Aristotle University of Thessaloniki, Thessaloniki, Greece · 10 - Department of Oral and Maxillofacial Radiology, Univ. Lille, Lille University Hospital, Lille, France · 11 - Université de Perpignan Via Domitia, UMR7194/HNHP, Perpignan, France · 12 - Centre Européen de Recherches Préhistoriques/EPCC, Tautavel, France · 13 - Laboratoire Histoire Naturelle de l’Homme Préhistorique (HNHP), UMR7194, Département de Préhistoire du Muséum National d’Histoire Naturelle, Paris, France

The Middle Pleistocene, or Chibanian, is a complex period in human evolution due to the scarcity and morphological diversity of fossils from 600,000 to 300,000 years ago across Europe, Africa, and Asia. The species *Homo heidelbergensis* is central to understand human evolution during that period, but its hypodigm remains debated. Some authors extend the geographical range of *H. heidelbergensis* (sensu lato) to Asia and Africa [1], including fossils that could be ancestral to the *Homo sapiens* lineage like the Kabwe and Bodo crania, at the risk of making this species a possible “wastebasket” [1]. Conversely, some researchers define *H. heidelbergensis* (sensu stricto) as a European taxon, beginning with specimens like the Mauer mandible (c. 610,000 years) [2] and evolving into Neanderthals (and perhaps also into Denisovans). The classic chronospecies hypothesis aligns with the accretion model, where Neanderthal features gradually emerged over time through various anatomical systems, contributing to Neanderthal apomorphies at different evolutionary rates. However, other scholars argue that the large morphological variation seen in fossils from similar periods in Europe suggests multiple lineages (or paleodemes) coexisted.

The Ruidera fossil site, dated to approximately 300,000–350,000 years ago in Castilla-La Mancha (Southern Iberian Plateau), adds to this debate. First presented in 2022 as a site with human activity, recent excavations (2023–2024) have uncovered over 60 human fossil specimens, including dental, cranial, and postcranial fragments, all exceptionally well-preserved. Alongside other key sites like Atapuerca, Gruta de Aroeira, and Bolomor, Ruidera now stands as one of the most informative human fossil assemblages in the Iberian Peninsula.

In this study, we conducted 3D geometric morphometric (3DGM) analyses of four molars from Ruidera: UM1, UM2, LM2, and LM3. These specimens were compared with several Pleistocene to Holocene human specimens/taxa, following the digitalization protocol from Davies et al. [3] and using diffeomorphic surface matching [4]. Our results show that the Ruidera molars exhibit a more plesiomorphic EDJ morphology than in later *Homo*, characterized by a relatively short EDJ across all specimens. Neanderthal apomorphies are expressed in some of the Ruidera sample, such as the lingually protruding hypocone in the UM1 and the well-expressed anterior fossa in LM2. However, the EDJ of the LM3 shows no complete trigonid crest and no anterior fovea, as in the Mauer and Mala Balanica mandibular molars.

In conclusion, the Ruidera site has significant potential to contribute to the debate surrounding the origins of the Neanderthal (and Denisovan?) lineage(s). The combination of low (*H. erectus*-like) EDJs, combined with some Neanderthal traits in the Ruidera molars, raises important questions about the presence of some unknown human group in the Iberian Peninsula well into the Middle Pleistocene. While Sima de los Huesos already shows Neanderthal characteristics around 100,000 years earlier [5], the unique combination of morphological traits found in the Ruidera fossils may help resolve whether a single Neanderthal lineage dominated the region or if multiple lineages coexisted into the late Middle Pleistocene. Further analysis of these specimens will be crucial for understanding the complexities of hominin evolution during this period.

This research is funded by Leakey Foundation project ID: 45148 (2024-2025) entitled “Paleoanthropological investigation at Ruidera-Los Villares: Deciphering Middle Pleistocene Enigma in Western Europe”; and also, by Fundación PALARQ project entitled “Desvelando la Cronología del Pasado Humano: Análisis Multimétodo de Datación en el Yacimiento de Ruidera-Los Villares, Pleistoceno Medio”. We acknowledge the neighbours and institutions from Ruidera for their hospitality as well as Junta de Comunidades de Castilla-La Mancha and Parque Natural de las Lagunas de Ruidera for awarding the permits for the excavation. We also want to acknowledge the entire excavation team for their great and selfless work. We would like to express our gratitude to Prof. Guillaume Billet and Prof. Amélie Violet for their kind assistance with accessing the micro-CT data of fossils curated at the MNHN. Finally, we would also like to express our gratitude to Prof. Matthew Skinner and Thomas Davies for their contribution to open science by uploading 3D coordinates to open repositories.

References: [1] Bae, C.J., Aiello, L.C., Hawks, J., Kaifu, Y., Lindal, J., Martínón-Torres, M., Ni, X., Posth, C., Radović, P., Reed, D., Schroeder, L., Schwartz, J.H., Silcox, M.T., Welker, F., Wu, X., Zanolli, C., Roksandic, M., 2023. Moving away from “the Muddle in the Middle” toward solving the Chibanian puzzle. *Evolutionary Anthropology: Issues, News, and Reviews*. 33. [2] Rosas, A., Bermúdez De Castro, J.M., 1998. The Mauer mandible and the evolutionary significance of *Homo heidelbergensis*. *Geobios*. 31, 687–697. [3] Davies, T.W., Gunz, P., Spoor, F., Alemseged, Z., Gidna, A., Hublin, J.-J., Kimbel, W.H., Kullmer, O., Plummer, W.P., Zanolli, C., Skinner, M.M., 2024. Dental morphology in *Homo habilis* and its implications for the evolution of early Homo. *Nature Communications*. 15. [4] Zanolli, C., Davies, T.W., Joannes-Boyau, R., Beaudet, A., Bruxelles, L., de Beer, F., Hoffman, J., Hublin, J.-J., Jakata, K., Kgasi, L., Kullmer, O., Macchiarelli, R., Pan, L., Schrenk, F., Santos, F., Stratford, D., Tawane, M., Thackeray, F., Xing, S., Zipfel, B., Skinner, M.M., 2022. Dental data challenge the ubiquitous presence of *Homo* in the Cradle of Humankind. *Proceedings of the National Academy of Sciences*. 119. [5] Martínez de Pinillos, M., Martínón-Torres, M., Skinner, M.M., Arsuaga, J.L., Gracia-Téllez, A., Martínez, L., Martín-Francés, L., Bermúdez de Castro, J.M., 2014. Trigonid crests expression in Atapuerca-Sima de los Huesos lower molars: Internal and external morphological expression and evolutionary inferences. *Comptes Rendus Palevol*. 13, 205–221.

Poster Presentation Number 60, Session 1, Thursday 14:00 - 15:30

## Identification of fossil hominin cranial fragments: a computer vision-based approach

Eliott Gilet<sup>1,2</sup>, Noël Richard<sup>1</sup>, Christine Fernandez-Maloigne<sup>1</sup>, Jonathan Shock<sup>3</sup>, Muriel Mescam<sup>4</sup>, Jérôme Surault<sup>2</sup>, Gideon Chinamatira<sup>5</sup>, Dominic Stratford<sup>6,7</sup>, Amélie Beaudet<sup>2,6,8</sup>

1 - Laboratoire XLIM, UMR 7252 CNRS & Université de Poitiers, France · 2 - Laboratoire de Paléontologie, Évolution, Paléoécosystèmes et Paléoprimatologie (PALEVOPRIM), UMR 7262 CNRS & Université de Poitiers, France · 3 - Department of Maths and Applied Maths, University of Cape Town, South Africa · 4 - Centre de Recherche Cerveau et Cognition (CerCo), UMR 5549 CNRS & Université de Toulouse, France · 5 - Evolutionary Studies Institute, University of the Witwatersrand, South Africa · 6 - School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, South Africa · 7 - Stony Brook University, Stony Brook, New York, USA · 8 - Department of Archaeology, University of Cambridge, United-Kingdom

Cranial fragments are among the most commonly recovered hominin remains in the fossil record (e.g., [1]). Despite their potential to contribute to taxonomic discussions [2-3], these fragments are often difficult to anatomically assign, especially when originating from the cranial vault, and this is particularly true for Plio-Pleistocene hominin assemblages. As a result, isolated cranial fragments that cannot be confidently identified are frequently excluded from analyses, leading to the loss of valuable data on early hominin cranial anatomy. Improving our ability to determine the anatomical location of these isolated remains would not only increase the number of specimens available for study, but also enhance our understanding of the evolutionary processes (whether neutral or adaptive) having shaped the hominin cranium and facilitate more detailed reconstructions of hominin brain changes through the description of endocranial imprints. Within this context, our project aims to develop a computer vision-based approach for automatically identifying the anatomical position of isolated fossil hominin cranial remains based on a number of predefined textural, structural and geometrical criteria.

Our image-based approach relies on the quantitative analysis of bone properties across complete extant human crania from the Pretoria Bone Collection of the University of Pretoria (South Africa) and from PALEVOPRIM (France) which were scanned using micro-tomography at the South African Nuclear Energy Corporation (Necsa) and at the PLATINA (IC2MP) platform in Poitiers, respectively, and served as references. We focused on identifying and prioritizing a set of diagnostic features described in the literature as informative for cranial bone identification, that includes the presence and morphology of cranial sutures, bone curvature, bone thickness, structural arrangement of the diploic layer and inner and outer tables, as well as bone density [2-4]. Our approach, partly based on existing literature combining 3D data and computer-assisted methods (e.g., [5]), consists in extracting different types of gradients (e.g., curvature, density, thickness) associated with specific locations in the cranium by comparison with a reference model. We applied this approach to hominin cranial fragments recovered from the site of Sterkfontein and scanned at the Evolutionary Studies Institute of the University of the Witwatersrand (South Africa).

Our approach offers a reliable framework for testing hypotheses about the anatomical identification of isolated cranial fragments, as well as for generating informed proposals regarding the possible anatomical origin of undetermined specimens within the hominin fossil record. Moreover, this work constitutes a foundational step toward more comprehensive studies integrating the morphological complexity of the hominin cranium and, ultimately, proposing tentative reconstructions of entire crania from fragmentary remains, thereby expanding the available dataset for investigating cranial evolution in early hominins.

We are grateful to A. Mazurier (IC2MP), L. Bam, F. de Beer and J. Hoffman (Necsa) for scanning. This project has received financial support from the CNRS through the MITI interdisciplinary program "Jumeaux Numériques" and the CNRS Junior Professor Chair "Hominines".

References: [1] Wood, B., 1991. Koobi Fora Research Project Volume 4: Hominid cranial remains. Oxford University Press, New York. [2] Copes, L.E., Kimbel, W.H., 2016. Cranial vault thickness in primates: *Homo erectus* does not have uniquely thick vault bones. *Journal of Human Evolution*. 90, 120–134. [3] Beaudet, A., Carlson, K.J., Clarke, R.J., de Beer, F., Dhaene, J., Heaton, J.L., Pickering, T.R., Stratford, D., 2018. Cranial vault thickness variation and inner structural organization in the StW 578 hominin cranium from Jacovec Cavern, South Africa. *Journal of Human Evolution*. 121, 204–220. [4] White, T.D., Folkens, P.A., 2006. *The Human Bone Manual*. Elsevier, New York. [5] Li, J., Gsaxner, C., Pepe, A., Schmalstieg, D., Kleesick, J., Egger, J., 2023. Sparse convolutional neural network for high-resolution skull shape completion and shape super-resolution. *Scientific Reports*. 13, 20229.

Poster Presentation Number 61, Session 1, Thursday 14:00 - 15:30

## Argument for a progressive Aurignacian-to-Gravettian transition in southern Iberia based on the stone tool assemblages from La Boja rock-shelter (Mula, Murcia, Spain)

Luís Gomes<sup>1</sup>

<sup>1</sup> - UNIARQ - Centro de Arqueologia da Universidade de Lisboa, Faculdade de Letras de Lisboa, Universidade de Lisboa / UNIARQ – Centre for Archaeology, School of Arts and Humanities, University of Lisbon

Few studies have addressed the time and mode of the replacement of the Aurignacian by the Gravettian in southern Iberia and its implications for our understanding of the technological and cultural dynamics of Upper Palaeolithic societies. The lithic assemblages from the La Boja rock-shelter provide insights on the validity of two competing models, namely whether that replacement was a deep break – potentially correlated with demographic processes [1] – or a progressive, local transition, as suggested by technological data from elsewhere in southwestern Europe [2].

Located on the Rambla Perea canyon, a tributary of the Mula river and a natural corridor between the interior and the littoral, La Boja yielded several discrete occupation surfaces defined by well-preserved hearths grouped into occupation horizons (OH), with chronologies ranging from the Middle Palaeolithic to the Neolithic as determined by C-14 dates and material culture. OH11b-OH20, one of the best-preserved stretches of the sequence, includes depositional phases from the Late Gravettian (OH11b-OH12a), Early Gravettian (OH12b-OH14), Late Aurignacian (OH15-OH16) and Evolved Aurignacian (OH17-OH20) [3]. Due to the virtually complete Aurignacian-Gravettian sequence and the high level of integrity of the occupation surfaces revealed by the well-preserved hearths and the abundant lithic remains, this is a key site to understand the transition from one to the other.

We carried out technological and typological analyses of the lithic remains from the OH11b-OH20 sequence (11,470 pieces) and systematic refitting, always considering each discrete occupation surface as an individual unit of analysis. In what concerns the Evolved Aurignacian, Late Aurignacian and Early Gravettian phases, virtually no inter-OH or inter-phase refits were found. From a technological point of view, each phase is distinct. The Late Aurignacian phase shows aspects that will become characteristic in the Early-Gravettian lithic technology, namely the abandonment of endscraper-type cores, the predominance of prismatic cores, and the introduction of backing as a mode of retouch, evident in the abundant short-backed bladelets, a type that can be taken as a precursor to the backed tools that define the Gravettian. From a metric standpoint, blades and bladelets increase in size, becoming longer and wider, as we move from the Evolved to the Late Aurignacian, a tendency that continues into the Early Gravettian.

These results suggest that, in the region, the change from Evolved Aurignacian to Early Gravettian was a gradual transition. The Late Aurignacian remains poorly known in southern Iberia, although, considering the data available from Western Iberia [4], there are arguments to support that lithic systems underwent regionalization during this phase. Overall, the available evidence is consistent with the hypothesis that the Gravettian did not originate in a specific place from where it then diffused but represents instead a pan-European, synchronous, and multifaceted transformation of the leptolithic industries of the preceding Aurignacian.

This work was financed by Portuguese funds through FCT - Fundação para a Ciência e a Tecnologia in the framework of the PhD Grant SFRH/BD/144206/2019

References: [1] Bicho, N., Cascalheira, J., Gonçalves, C., 2017. Early Upper Paleolithic colonization across Europe: Time and mode of the Gravettian diffusion. *PLoS ONE*. 12, e0178506. [2] Pesesse, D., 2010. Quelques repères pour mieux comprendre l'émergence du Gravettien en France. *Bulletin de la Société préhistorique française*. 107, 465–487. [3] Zilhão, J., Anesin, D., Aubry, T., Badal, E., Cabanes, D., Kehl, M., Klasen, N., Lucena, A., Martín-Lerma, I., Martínez, S., Matias, H., Susini, D., Steier, P., Wild, E.M., Angelucci, D.E., Villaverde, V., Zapata, J., 2017. Precise dating of the Middle-to-Upper Paleolithic transition in Murcia (Spain) supports late Neandertal persistence in Iberia. *Heliyon*. 3, e00435. [4] Zilhão, J., Davis, S.J.M., Duarte, C., Soares, A.M.M., Steier, P., Wild, E., 2010. Pego do Diabo (Loures, Portugal): Dating the Emergence of Anatomical Modernity in Westernmost Eurasia. *PLoS ONE*. 5, e8880.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## Reassessing the Montmaurin-La Niche mandible: divergent phylogenetic signals and implications for hominin diversity during MIS 7

Flavien Gomez<sup>1</sup>, Laura Martín-Francés<sup>2,3</sup>, Marina Martinez de Pinillos<sup>2,4</sup>, Maria Martín-Torres<sup>2,4,5</sup>, José María Bermúdez de Castro<sup>2</sup>, Amélie Vialet<sup>6</sup>

1 - UMR 7194 – HNHP (CNRS), University of Perpignan, France – UPVD · 2 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Burgos, Spain · 3 - Monash Biomedicine Discovery Institute, Department of Anatomy and Developmental Biology, Monash University, Melbourne, Australia · 4 - Laboratorio de Evolucion Humana (LEH), Departamento de Ciencias Históricas y Geografía, Universidad de Burgos, Burgos, Spain · 5 - Department of Anthropology, University College, London, UK · 6 - Muséum national d'Histoire naturelle, UMR 7194 – HNHP (CNRS), UPVD

The Montmaurin-La Niche mandible was discovered in 1949 within a chimney of the karstic system of the Montmaurin massif (Haute-Garonne, France) and firstly described by G. Billy and H.-V. Vallois [1]. The associated faunal remains were attributed to Marine Isotope Stage 7 [2] whereas new datings, obtained by <sup>26</sup>Al/<sup>10</sup>Be and ESR-U/Th methods, largely open the chronological bracket between 150 to 760 ka. The Montmaurin-LN mandible is remarkable for the discrepancy between the phylogenetic signals conveyed by its dentition and its mandibular morphology. Vialet et al. [3] emphasized that the mandible shares few traits with Neandertals, in contrast to the dental crown morphology, which aligns more closely with the Neandertal condition. This observation was later refined by Martínez de Pinillos et al. [4], who showed that the internal morphology of the teeth is also consistent with that of Neandertals, whereas the enamel thickness, like the mandibular features, remains more closely related to Early Middle Pleistocene hominins.

Given these conflicting signals, it is essential to consider this specimen within the broader morphological variability of Middle Pleistocene hominins. Using a cladistic approach based on the ASUDAS system for non-metric dental traits (45 characters) and 39 mandibular traits, this study compares the phylogenetic signals derived from both mandibles and lower teeth and aims to determine the phylogenetic relationships between fossils. It includes a comparative sample of mandibles (n=36) and lower teeth (n=368) from Middle Pleistocene sites across Europe and the Levant, treated as operational taxonomic units (OTUs) and analyzed both independently and in combination. A method involving the use of median value of character states is also tested for filling the matrices.

The results confirm the discordance between the dental and mandibular signals in the Montmaurin-LN specimen: while the mandible retains plesiomorphic traits, the teeth display a distinct Neandertal morphology. Mandibular characters appear to have had a greater influence than dental traits, both in shaping the overall tree topology and in contributing a larger number of informative characters. Nevertheless, dental traits reinforced most nodes and had a significant impact on the placement of certain OTUs. Highlighting the importance of incorporating all available data in future analyses. When placed within the context of MIS 7 in Europe, this study highlights a period of marked morphological variability. While certain fossils from this time (Ehringsdorf, La Chaise Bourgeois-Delaunay) already exhibit the classic Neandertal morphology, others (Payre, Montmaurin) occupy more ambiguous positions, suggesting that Neandertal traits may have emerged asynchronously across different anatomical regions.

References: [1] Billy G., Vallois H.V., 1977. La mandibule pré-rissienne de Montmaurin, *L'Anthropologie*, 81, 273-312, 411-458. [2] Crégut-Bonnoure, E., Boulbes, N., Guérin, C., Pernaud, J., Tavoso, A., Cammas, R., 2010. Le contexte géomorphologique et faunique de l'homme de Montmaurin (Haute-Garonne). *Préhistoires Méditerranéennes*, 1, 3-85. [3] Vialet, A., Modesto-Mata, M., Martín-Torres, M., Martínez de Pinillos, M., Bermúdez de Castro, J.-M., 2018. A reassessment of the Montmaurin-La Niche mandible (Haute Garonne, France) in the context of European Pleistocene human evolution. *PLOS ONE*, 13, e0189714. [4] Martínez de Pinillos, M., Martín-Francés, L., de Castro, J.M.B., García-Campos, C., Modesto-Mata, M., Martín-Torres, M., Vialet, A., 2020. Inner morphological and metric characterization of the molar remains from the Montmaurin-La Niche mandible: The Neandertal signal. *Journal of Human Evolution*, 145, 102739.

Poster Presentation Number 62, Session 1, Thursday 14:00 - 15:30

## The shape and function of *Rectus Abdominis* muscle in humans: 4D geometric morphometrics analysis and evolutionary implications

Marta Gómez-Recio<sup>1,2,3,4</sup>, Benoit Beyer<sup>2</sup>, Barbara Fischer<sup>4,5</sup>, Elena García Vargas<sup>6</sup>, Vladimir Sladek<sup>6</sup>, Markus Bastir<sup>1</sup>

1 - Grupo de Paleantropología, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (MNCN-CSIC), Madrid, Spain · 2 - Laboratory of Anatomy Biomechanics and Organogenesis, Université Libre de Bruxelles, Brussels, Belgium · 3 - Universidad Autónoma de Madrid, Madrid, Spain · 4 - Konrad Lorenz Institute for Evolution and Cognition Research, Klosterneuburg, Austria · 5 - Unit for Theoretical Biology, Department of Evolutionary Biology, University of Vienna, Vienna, Austria · 6 - Charles University, Prague, Czech Republic

Through evolution, major changes in the hominin *bauplan* led to bipedalism and, with it, to the verticalization of the abdominal wall, affecting its biomechanics. The abdominal wall plays a critical role in locomotion, body support and respiratory function in humans. Specifically, in the context of the respiratory system, the Rectus Abdominis muscle (RAM) plays an important role during expiration at intense exercise, helping increase intra-abdominal pressure by compressing the abdomen and moving the ribcage. Across literature, different anatomical features of *Homo* fossils have been associated with endurance running performance [1,2].

However, the studies considering the importance of the respiratory function from a holistic evolutionary perspective are still limited. This study presents the first in-vivo assessment of RAM shape in a balanced sample of 36 male and female sprinters and endurance runners. Shape was captured using 58 landmarks placed directly onto high-resolution CT scan slices at functional residual capacity (FRC), following a standardised protocol. Subsequent 3DGM analysis revealed significant differences in RAM shape by sex and running type (Procrustes Anova,  $p$ -value<0.05). To further understand the functionality of RAM, the athletes underwent a second CT scan while they were asked to take in air to total lung capacity (TLC). We applied a novel methodology to extract the motion vectors between TLC and FRC RAM shape configurations, therefore measuring the shape variation. This could be related to potential mechanical advantage of the muscle during expiration. The spring constant (i.e. the stiffness of this muscle), may have important functional implications for its ability of generating passive tension [3], facilitating the efficient return of the muscle to its resting shape at the beginning of forced expiration, reducing the energetic requirements of contraction. Stiffer muscles may be more efficient during sustained respiratory effort, as they rely less on active contraction to return to their functional baseline. However, motion vector analysis revealed no functional differences in RAM motion between groups (permutation test,  $p$ -value>0.05).

Our findings reveal that despite there are morphological differences in RAM across sex and running specialization, no differences in its FRC to TLC shape change could be found. This might imply that respiratory function of this muscle could be functionally conserved in physically active humans, highlighting the importance of this muscle in breathing mechanics. In the context of human evolution, this study underscores the importance of integrating experimental functional analysis with shape analysis when making inferences about body function across the fossil record. Future studies integrating electromyographic activity and physiological data of this and other respiratory muscles could provide deeper insights into the interplay between morphology, muscle activation, and respiratory biomechanics.

MGR is funded by PIPF-2023/SAL-GL-30162 PhD grant (Comunidad de Madrid, Spain) and by a KLI Writing-Up Resident Fellowship (Austria). MB is funded by PID2020-115854GB-I00 of the Spanish Ministry of Science and Innovation.

References: [1] Bramble, D.M., Lieberman, D.E., 2004. Endurance running and the evolution of *Homo*. *Nature*. 432, 345–352. [2] Bastir, M., González Ruíz, J.M., Rueda, J., Garrido López, G., Gómez-Recio, M., Beyer, B., San Juan, A.F., Navarro, E., 2022. Variation in human 3D trunk shape and its functional implications in hominin evolution. *Scientific Reports*. 12. [3] The heat of shortening and the dynamic constants of muscle, 1938. *Proceedings of the Royal Society of London. Series B - Biological Sciences*. 126, 136–195.

Podium Presentation, Session 7, Saturday 08:30 – 10:30

## Linking microevolution, macroevolution and genetics to elucidate craniofacial diversification in great apes and humans

Aida Gómez-Robles<sup>1,2</sup>, Alfie Gleeson<sup>1,2</sup>, Aida M. Andrés<sup>2</sup>

1 - Department of Anthropology, University College London · 2 - Department of Genetics, Evolution and Environment, University College London

Given the widespread geographical distribution of humans across vastly diverse ecosystems, as well as the role of individual recognition in human social interactions, it has been hypothesized that human craniofacial diversity is particularly high in comparison with other species [1]. A high level of diversity may have also facilitated long-term evolution in some species of the genus *Homo* [2]. However, with some notable exceptions [3], comparisons between humans and great apes tend to focus on interspecific differences rather than on intraspecific variation and the way that it influences long-term evolution.

We compared levels of intraspecific craniofacial diversity in a large sample of adult hominids, including geographically diverse recent modern humans (n=52) and most species and subspecies of extant great apes (*Pongo*=29; *Gorilla*=72; *Pan*=136). We used 3D high-density geometric morphometric configurations of landmarks, curve, and surface semilandmarks to accurately describe all aspects of craniofacial variation, and we compared craniofacial diversity with genetic diversity as measured by genome-wide heterozygosity for each taxon [4]. The effect of sexual dimorphism was controlled by using allometry-corrected shape residuals, as sexual dimorphism is linked to size variation, and by repeating analyses in male-only and female-only samples. In addition, intraspecific craniofacial diversity was compared with species-specific evolutionary rates, which were calculated using phylogenetic comparative methods and simulations of shape evolution along the branches of the hominid phylogeny.

Our results indicate that neurocranial diversity tracks genetic diversity across the great apes, but facial diversity does not, suggesting that environmental factors influence facial variation more strongly. The association between genetic and craniofacial diversity holds for all great apes but for the two subspecies of Eastern gorillas (*G. beringei beringei* and *G. beringei graueri*), where very low genetic diversity is associated with transgressive morphologies and increased craniofacial variation [5].

Within this general pattern of variation, humans show a low level of craniofacial diversity in comparison with the other great apes, which is expected from the comparatively low levels of genetic diversity in humans, but unexpected based on human wide geographical distribution. Matching the general pattern of variation observed across the great apes, neurocranial variation is low in humans, but facial variation shows higher diversity than expected given the low level of genetic diversity.

Despite their overall low level of genetic and craniofacial diversity, humans show the highest evolutionary rate for craniofacial shape, pointing to non-neutral mechanisms shaping craniofacial evolution in humans, or to constrained evolution in the great apes. Conversely, groups with the highest levels of intraspecific variation, both orangutans species and Eastern gorillas, show generally low evolutionary rates, thus indicating that there is no clear link between elevated intraspecific diversity and accelerated evolution.

A.G.-R. is supported by a Royal Society-Leverhulme Trust Senior Research Fellowship (SRF\R1\241038). This work was also supported by the Biotechnology and Biological Sciences Research Council via a London Interdisciplinary Doctoral Training Programme studentship to A.G (BBSRC grant number BB/M009513/1).

References: [1] Sheehan, M.J., Nachman, M.W., 2014. Morphological and population genomic evidence that human faces have evolved to signal individual identity. *Nature Communications*. 5, 4800. [2] Baab, K.L., 2021. Reconstructing cranial evolution in an extinct hominin. *Proceedings of the Royal Society B: Biological Sciences*. 288, 20202604. [3] Zichello, J.M., Baab, K.L., McNulty, K.P., Raxworthy, C.J., Steiper, M.E., 2018. Hominoid intraspecific cranial variation mirrors neutral genetic diversity. *Proceedings of the National Academy of Sciences*. 115, 11501–11506. [4] Prado-Martinez, J., Sudmant, P.H., Kidd, J.M., Li, H., Kelley, J.L., Lorente-Galdos, B., Veeramah, K.R., Woerner, A.E., O'Connor, T.D., Santpere, G., Cagan, A., Theunert, C., Casals, F., Laayouni, H., Munch, K., Hobolth, A., Halager, A.E., Malig, M., Hernandez-Rodriguez, J., Hernando-Herraez, I., Prüfer, K., Pybus, M., Johnstone, L., Lachmann, M., Alkan, C., Twigg, D., Petit, N., Baker, C., Hormozdiari, F., Fernandez-Callejo, M., Dabad, M., Wilson, M.L., Stevison, L., Camprubi, C., Carvalho, T., Ruiz-Herrera, A., Vives, L., Mele, M., Abello, T., Kondova, I., Bontrop, R.E., Pusey, A., Lankester, F., Kiyang, J.A., Bergl, R.A., Lonsdorf, E., Myers, S., Ventura, M., Gagneux, P., Comas, D., Siegmund, H., Blanc, J., Agueda-Calpena, L., Gut, M., Fulton, L., Tishkoff, S.A., Mullikin, J.C., Wilson, R.K., Gut, I.G., Gonder, M.K., Ryder, O.A., Hahn, B.H., Navarro, A., Akcey, J.M., Bertranpetit, J., Reich, D., Mailund, T., Schierup, M.H., Hvilsom, C., Andrés, A.M., Wall, J.D., Bustamante, C.D., Hammer, M.F., Eichler, E.E., Marques-Bonet, T., 2013. Great ape genetic diversity and population history. *Nature*. 499, 471–475. [5] McGrath, K., Eriksen, A.B., García-Martínez, D., Galbany, J., Gómez-Robles, A., Massey, J.S., Fatica, L.M., Glowacka, H., Arbenz-Smith, K., Muvunyi, R., Stoinski, T.S., Cranfield, M.R., Gilardi, K., Shalukoma, C., de Merode, E., Gilissen, E., Tocheri, M.W., McFarlin, S.C., Heuzé, Y., 2022. Facial asymmetry tracks genetic diversity among *Gorilla* sub species. *Proceedings of the Royal Society B: Biological Sciences*. 289.

Poster Presentation Number 63, Session 1, Thursday 14:00 - 15:30

## Testing the limits of AI and machine learning for quantitative taphonomy. Skeletal-part representation as a proxy for the origins of human deposition

Jonas Grabbe<sup>1,2</sup>, Ana Pantoja-Pérez<sup>1,3</sup>, Ana Serrano-Mamolar<sup>2,4</sup>, Antonio Canepa-Oneto<sup>2,4</sup> and Nohemi Sala<sup>1,3</sup>

1 - Centro Nacional de Investigación sobre la Evolución Humana, Burgos, Spain · 2 - Universidad de Burgos, Burgos, Spain · 3 - Centro Mixto UCM-ISCIH de Evolución y Comportamiento Humanos, Madrid, Spain · 4 - Advanced Data Mining Research And (Business intelligence | Bioinformatics | Big Data) LEarning, Escuela Politécnica Superior, Burgos, Spain

The analysis of skeletal-part representation provides a valuable approach within taphonomic research. Differential bone preservation can provide inferences regarding biostratigraphic processes, such as episodes of rapid burial linked to funerary behaviors or catastrophic events. However, these patterns can also be significantly altered by fossil-diagenetic processes and excavation circumstances, potentially obscuring the original depositional signals. Furthermore, subtle variations in mortuary or funerary practices—from formal burials to surface deposition—can leave distinct yet easily confounded traces in the assemblage. Without a rigorous integration of geological history, sedimentary context, and detailed taphonomic analyses, interpretations of past behaviors risk conflating cultural signals with post-depositional biases.

In this context, machine learning (ML) approaches offer a complement to traditional taphonomic methods, potentially reducing the subjective biases inherent in traditional visual interpretation. Recently, ML and artificial intelligence (AI) techniques have rapidly expanded in archaeological and paleoanthropological research, with applications extending across diverse taphonomic contexts [1]. Despite their growing adoption, the overall use and effectiveness of ML techniques in taphonomic research remain underexplored. This is primarily due to their recent introduction to the field and the limited availability of high-quality, abundant data.

In this study, we present a comprehensive database of more than 120 sites with Skeletal-Part representation and an analytical pipeline that applies ML techniques for standardized analysis to a subset of this database. This approach enables reproducible classification of taphonomic signatures and supports large-scale comparative studies of depositional behaviors. To build this dataset, we standardized abundance records from the paleoanthropological sites, encompassing skeletal-part representation data from more than 1,000 individuals. Each record incorporates detailed element identification including laterality, geological contexts, chronological periods, and specific depositional contexts (e.g., cannibalism, carnivore activity, geological transport, or funerary practices). Where available, we also distinguished between funerary behaviors, including inhumation, collective burial, and funerary caching.

Raw Minimum Number of Elements (MNE) data were transformed into standardized quantitative variables—such as Minimum Number of Anatomical Units (MNAU), percentage MNAU (%MNAU), and Relative MNAU (ReMNAU). We used various imputation techniques to achieve consistent bone-level resolution across sites. These curated datasets were then analyzed using supervised machine learning classifiers, including Random Forest, Support Vector Machines, and other advanced AI methods, to differentiate the cause of the accumulation and varying bone-level resolution. Model robustness was assessed through stratified cross-validation using metrics such as accuracy, precision, recall, F1-score, and ROC-AUC. Finally, we analyzed the effect of bone-level granularity on classification performance, assessing how detailed anatomical resolution influenced the accuracy of taphonomic predictions.

Despite ongoing challenges, including post-depositional disturbances and limited sample sizes, our results highlight specific anatomical patterns that most effectively signal different depositional origins. By automating taphonomic classification with transparent, open-access tools, reproducibility across paleoanthropology can be enhanced. Clarifying both the strengths and limitations of ML/AI approaches applied to rigorously curated skeletal datasets, our work enables large-scale comparative analyses of hominin depositional behavior and offers novel quantitative insights into the fossil record.

This research has received funding from the European Research Council under the European Union's Horizon 2020 research and innovation program (Grant agreement No. 949330) and PID2021-122355NB-C31 and PID2021-122355NB-C33 funded by MCIN/AEI/10.13039/501100011033/FEDER, UE. NS has received funding from the Ministerio de Ciencia e Innovación under the Ramón y Cajal program (RYC2020-029656-I) funded by MCIN/AEI/10.13039/501100011033 and El FSE invierte en tu futuro. The authors wish to thank the DEATHREVOl team.

References: [1] Bellat, M., Figueroa, J.D.O., Reeves, J.S., Taghizadeh-Mehrjardi, R., Tennie, C., Scholten, T., 2025. Machine learning applications in archaeological practices: a review. arXiv preprint arXiv:2501.03840.

Poster Presentation Number 64, Session 1, Thursday 14:00 - 15:30

## Lower limbs and locomotion: can muscle architecture in living primates indicate locomotor mechanisms in fossil hominins?

Emma Guimaraes<sup>1</sup>, Evie Vereecke<sup>2</sup>, Ashleigh Wiseman<sup>1,3</sup>

1 - Department of Anthropology, University College London, London, UK · 2 - Department of Development and Regeneration, KU Leuven Campus Kulak, Kortrijk, Belgium · 3 - McDonald Institute for Archaeological Research, University of Cambridge, Cambridge, UK

The relationship between muscle architecture and locomotor function is essential for interpreting primate locomotor diversity. Key parameters such as fibre length, pennation angle and physical cross-sectional area (PCSA) influence force generation, yet these variables vary widely across taxa. Comparative studies focusing on these functional traits are crucial for uncovering how different musculoskeletal architectures support a broad range of locomotor behaviours in primates. Many primate species can walk bipedally for short distances, demonstrating that bipedalism is part of a broad spectrum of locomotor strategies shaped by ecological and anatomical constraints. To fully understand the evolutionary pathway to habitual bipedalism in the hominin lineage, it is essential to explore musculoskeletal function across a broad range of primate species.

By building a comprehensive comparative dataset, we aim to 'phylogenetically bracket' hominin musculature and support accurate soft tissue reconstructions in extinct hominins. The transition from quadrupedal locomotion to one of habitual bipedalism was likely not a linear one. Forms of arboreal locomotion such as clambering, climbing and indeed arboreal bipedalism would have played a fundamental part in the acquisition of a bipedal gait. Living primates exhibiting varying degrees of bipedal capacity, as well as diverse forms of arboreal and terrestrial locomotion provide a wide taxonomic, but also functionally informative, sample. Therefore, the broad sample used in this study allows us to explore and quantify diverse muscle architectures and apply these insights to hominins.

We compared the muscle architecture of the pelvis and lower limb of eight primate species and explored correlations between muscle properties and locomotion. We collected data during detailed dissections of seven extant primates representing a diverse range of locomotor types, from habitual bipeds to knuckle-walkers. The primates included in the study were: *Gorilla gorilla*, *Pongo abelii*, *Pan troglodytes*, *Pan paniscus*, *Hylobates lar*, *Symphalangus syndactylus* and *Macaca mulatta*. For each specimen, the right leg and pelvis were dissected, providing detailed topographical atlases of muscle paths, alongside measurements of fibre length, pennation angle, muscle belly and tendon mass and lengths. Specimens were opportunistically collected from European zoos post-mortem, with no animals sacrificed. The Animal Ethics Committee of KU Leuven was notified, and all work complied with EU regulations (approval codes M005/2023, M006/2023). Corresponding data for the remaining taxa, *Homo sapiens*, were taken from existing literature [1-2].

For each muscle in the pelvis and lower limb (n=45), we calculated PCSA and maximal isometric force (F<sub>max</sub>). Parameters were normalised by known body mass or body mass estimations using femoral circumference to allow comparison between different-sized animals. Analyses included functional space plots of fibre length versus PCSA, alongside principal components analysis to identify the key factors driving variation in muscle architecture and to examine how these differences relate to primary locomotor mode. Preliminary results indicate the biggest functional differences between primates lie in the distal muscles of the lower limb. For example, in orangutans and gibbons, muscles such as those supporting the ankle are adapted for powerful movements suited to suspension and leaping respectively, while in chimpanzees these muscles support strong push-off and weight-bearing during knucklewalking.

In this way, we offer new insights into how muscle architecture is phylogenetically constrained within the primate order, and how such a dataset can be used to estimate the architecture, and consequently locomotor capabilities of hominin individuals.

This research was supported by a Leverhulme Trust Early Career Fellowship (grant no. ECF-2021-054), the Isaac Newton Trust (Project\_21.08(a)) at the University of Cambridge and the AABA Cobb Professional Development Grant, all awarded to ALAW.

References: [1] Charles, J.P., Grant, B., D'Août, K., Bates, K.T., 2020. Subject-specific muscle properties from diffusion tensor imaging significantly improve the accuracy of musculoskeletal models. *Journal of Anatomy*. 237, 941–959. [2] Charles, J.P., Suntaxi, F., Anderst, W.J., 2019. In vivo human lower limb muscle architecture dataset obtained using diffusion tensor imaging. *PLOS ONE*. 14, e0223531.

Poster Presentation Number 65, Session 1, Thursday 14:00 - 15:30

## Hominin stone tool use: experimental insights into edge damage and raw material variability

Tamrat Kahsay Habtu<sup>1,2,3</sup>, Walter Gneisinger<sup>1,2</sup>, Tamara Dogandžić<sup>2,3</sup>, João Marreiros<sup>1,2,3,4</sup>

1 - Kompetenzbereich Pleistozäne und frühholozäne Archäologie und Laboratory for Traceology and Controlled Experiments. Schloss Monrepos, Neuwied · 2 - Leibniz-Zentrum für Archäologie. Standort Neuwied MONREPOS. Archaeological Research Centre and Museum for Human Behavioural Evolution · 3 - Institute for Prehistoric and Protohistoric Archaeology, Johannes Gutenberg University, Mainz, Germany · 4 - ICArEHB, Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour, University of Algarve, Faro, Portugal

This study examines the formation of edge damage in stone tools, exploring its relationship with raw material variability and stone tool use. Through experimental archaeology and multi-scale analysis, we investigate how edge damage patterns in stone tools reflect intentional raw material selectivity, determining whether material choice brought functional benefits (e.g., durability) or was constrained by resource availability. By combining experimental archaeology and multi-scale analysis, we clarify how tool use dynamics and material properties jointly shaped prehistoric technological strategies. Firstly, the experimental study investigates how raw materials (obsidian, ignimbrite, basalt) and tool typology influence edge damage patterns. We apply the results to Early Pleistocene Acheulean lithic assemblages from the Melka Wakena site complex (MW2 & MW5), Ethiopian Highlands, ~1.62–0.6 Mya [1-3], investigating how edge damage patterns serve as a proxy for tool use and raw material selectivity [4-5]. This addresses whether Acheulean hominins strategically prioritised material properties for long-term tool efficiency within fluctuating environmental constraints.

Hand-knapped flakes from six raw materials: coarse-grained (basalt, quartzite, dacite) and fine-grained (flint, ignimbrite, obsidian) were tested under standardised cutting (900 contact angle) and scraping-like tasks (450 contact angle) on wood and artificial bone. Edge damage was documented at intervals of 250, 500, and 1000 strokes using macroscopic observation, 3d scanning, and 2D Edge Detection Field (EDF) analysis, and a detailed macroscopic observation.

The study will evaluate material-specific variations in edge damage type, frequency and distribution to challenge the assumption of uniformity across lithic materials. By integrating experimental frameworks with site-specific techno-typological analysis, this research aims to assess how raw material properties may have influenced tool-use behaviours among Early Pleistocene hominins. The investigation of archaeological assemblages will explore early hominin adaptability to material constraints, seeking insights into decision-making processes in tool production and use. This dual approach attempts to contribute to interpretive frameworks that link edge damage patterns to technological innovation, to refine perspectives on Acheulean technological and functional strategies.

Acknowledgements: MONREPOS. Archaeological Research Centre and Museum for Human Behavioural Evolution; Laboratory for Traceology and Controlled Experiments; Leibniz-Zentrum für Archäologie; Prinz-Maximilian-zu-Wied-Stiftung; Melka Wakena Paleoanthropological Research Project; Ethiopian Heritage Authority

References: [1] de la Torre, I., 2011. The Early Stone Age lithic assemblages of Gadeb (Ethiopia) and the Developed Oldowan/early Acheulean in East Africa. *Journal of Human Evolution*. 60, 768–812. [2] Gossa, T., Asrat, A., Hovers, E., Tholt, A.J., Renne, P.R., 2024. Claims for 1.9–2.0 Ma old early Acheulean and Oldowan occupations at Melka Kunture are not supported by a robust age model. *Quaternary Science Reviews*. 326, 108506. [3] Hovers, E., Gossa, T., Asrat, A., Niespolo, E.M., Resom, A., Renne, P.R., Ekshtain, R., Herzlinger, G., Ketema, N., Martínez-Navarro, B., 2021. The expansion of the Acheulean to the Southeastern Ethiopian Highlands: Insights from the new early Pleistocene site-complex of Melka Wakena. *Quaternary Science Reviews*. 253, 106763. [4] McPherron, S.P., Braun, D.R., Dogandžić, T., Archer, W., Desta, D., Lin, S.C., 2014. An experimental assessment of the influences on edge damage to lithic artifacts: a consideration of edge angle, substrate grain size, raw material properties, and exposed face. *Journal of Archaeological Science*. 49, 70–82. [5] Tringham, R., Cooper, G., Odell, G., Voytek, B., Whitman, A., 1974. Experimentation in the Formation of Edge Damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology*. 1, 171–196.

Podium Presentation, Session 10, Saturday 15:50 – 17:10

## Statistical shape modelling (SSM) reveals significant taxonomic variability in early Pleistocene hominin pelvises from South Africa

Martin Haeusler<sup>1</sup>, Nicole Torres Tamayo<sup>1</sup>, Laura M. Watson<sup>2,3</sup>, Mirella Woodert<sup>1</sup>, Guillermo Bravo Morante<sup>1</sup>, Stefan Schlager<sup>4</sup>, Nicole M. Webb<sup>1,2</sup>

1 - Institute of Evolutionary Medicine, University of Zürich, Zürich, Switzerland · 2 - Department of Palaeoanthropology, Senckenberg Research Institute and Natural History Museum Frankfurt, Frankfurt, Germany · 3 - Institute for Archaeological Sciences, University of Tübingen, Tübingen, Germany · 4 Department of Oral and Maxillofacial Surgery, Medical Center University of Freiburg, Freiburg, Germany

Various studies noted the remarkably high morphological variability of the fossil assemblages from South Africa, which repeatedly led to the proposition of new species [see, e.g., 1]. However, conflicting interpretations of both the geology of the sites and the morphology of the specimens, together with ambiguities regarding the attribution of individual specimens to the different taxa complicate our understanding of this time period. Most importantly, there is a lack of substantive quantitative evidence for many morphological assumptions. Recent work on the sacra of two partial early hominin skeletons, StW 431 and Sts 14, attributed to *Australopithecus africanus*, provided the first statistical support for taxonomic heterogeneity at Sterkfontein Member 4 (2.61–2.07 Ma) [2]. Using a detailed geometric morphometric analysis, this study concluded that the sacrum of Sts 14, a presumed female subadult *A. africanus* with an estimated body weight of 25.4 kg, was significantly different from StW 431, an almost twice as large (45 kg), alleged male adult individual. Specifically, the probability of sampling morphologies as distinct as these two fossils from a single extant species was 1.3% for a worldwide sample of modern human adult and subadult sacra, 0.0% for common chimpanzees, and 4.5% for lowland gorillas.

The fragmentary hipbone and sacrum of StW 431 have previously been reconstructed by mirror-imaging and realigning the preserved fragments of the left and right side [3]. Here, we present a novel full reconstruction of the StW 431 pelvis by estimating the missing parts of the ischium and pubis using statistical shape modelling (SSM). The SSM was performed based on the pooled data of 101 chimpanzee, 57 gorilla and 113 modern human hipbones of a worldwide sample [4]. When compared to an independent large fossil and extant comparative sample of 383 modern human pelvises (including 94 subadults), 42 chimpanzees, and 30 gorillas, all australopithecine pelvises plotted intermediate between modern humans and great apes. However, whereas Sts 14 grouped with A.L. 288-1 (*A. afarensis*) and MH2 (*A. sediba*), StW 431 is positioned separately in shape space as verified statistically by the corresponding Procrustes distances. This strongly supports the notion that these two specimens from Sterkfontein Member 4 belong to different species.

Adding to the complexity, a third adult *Australopithecus* hipbone from Sterkfontein Member 4, Sts 65, which is less studied due to its poor preservation, demonstrates an intermediate body mass falling between StW 431 and Sts 14 [3]. In agreement with previous interpretations regarding overall robusticity, our geometric morphometric analysis confirmed Sts 14 as a female and both Sts 65 and StW 431 as males. Using the SSM method, we also predicted the missing ischiopubic region of Sts 65, which allowed direct comparison of its hipbone morphology with our fossil and extant samples. Surprisingly, the PCA analysis revealed a greater morphological similarity of Sts 65 to modern humans than to either of the two australopithecine specimens. This unexpectedly high variability adds to the discussion of morphological variation in body size and taxonomic diversity within the Sterkfontein australopithecine assemblage, suggesting that multiple selection pressures were shaping hominins in this locality. To test the hypothesis that any of the australopithecines' hipbones from Sterkfontein evidence a trend towards the morphology of the later *Paranthropus robustus*, we also evaluated the SK3155 hipbone from Swartkrans Member 1 [5]. However, this revealed the existence of another distinct cluster in close proximity to modern humans which reaffirmed the uniqueness of Sts 65 relative to all fossil referents.

This work was funded by the Swiss National Science Foundation grant nos. 31003A\_156299 (M.H.) and 31003A\_176319 (M.H.) and is part of the Leibniz-Kooperative Exzellenz Project K438/2022 (N.M.W.).

References: [1] Clarke, R.J., Kuman, K., 2019. The skull of StW 573, a 3.67 Ma *Australopithecus prometheus* skeleton from Sterkfontein Caves, South Africa. *Journal of Human Evolution*. 134, 102634. [2] Fornai, C., Krenn, V.A., Mitteroecker, P., Webb, N.M., Haeusler, M., 2021. Sacrum morphology supports taxonomic heterogeneity of *Australopithecus africanus* at Sterkfontein Member 4. *Communications Biology*. 4, 347. [3] Haeusler, M., Ruff, C.B., 2020. Pelvis. In: Zipfel, B., Richmond, B.G., Ward, C.V. (Eds.), *Hominin Postcranial Remains from Sterkfontein, South Africa, 1936–1995*. Oxford University Press, Oxford, pp. 181–201. [4] Torres-Tamayo, N., VanSickle, C., Woodert, M., Haeusler, M., Schlager, S., submitted. Statistical Shape Modelling in Palaeoanthropology: A novel method for reconstructing missing pubic morphology in extinct hominins. *Methods in Ecology and Evolution*. [5] VanSickle, C., Haeusler, M., Woodert, M., Schlager, S., Torres-Tamayo, N., 2024. Perspectives on possible and probable *Paranthropus* pelvises. *PaleoAnthropology*. 2, 543.

Podium Presentation, Session 6, Friday 16:00 – 17:40

## Middle Pleistocene funerary ritual at Apidima? An examination of the evidence

Katerina Harvati<sup>1,2,3,4</sup>, Effrosyni Roditi<sup>1</sup>, Rainer Grün<sup>3,5</sup>, Nicholas Thompson<sup>1,4</sup>, Carolin Röding<sup>1</sup>, Vassileios Gorgoulis<sup>4,6,7,8,9</sup>, Konstantinos Evangelou<sup>4,6</sup>

1 - Paleoanthropology, Institute for Archaeological Sciences and Senckenberg Center for Human Evolution and Paleoenvironments, Eberhard Karls Universität Tübingen · 2 - Centre for Early Sapiens Behaviour (SapienCE), University of Bergen, Norway · 3 - DFG Centre for Advanced Studies 'Words, Bones, Genes, Tools', Eberhard Karls Universität Tübingen · 4 - Museum of Anthropology, Medical School, National and Kapodistrian University of Athens, Athens, Greece · 5 - Research School of Earth Sciences, the Australian National University, Canberra ACT 2601, Australia · 6 - Department of Histology and Embryology, Medical School, National and Kapodistrian University of Athens, Athens, Greece · 7 - Biomedical Research Foundation of the Academy of Athens, Athens, Greece · 8 - Ninewells Hospital and Medical School, University of Dundee, Dundee, UK · 9 - Faculty Institute for Cancer Sciences, Manchester Academic Health Sciences Centre, University of Manchester, Manchester, UK

The Apidima cave complex (Southern Greece) has yielded important paleoanthropological evidence, including human remains, Paleolithic artifact and fossil faunal assemblages. Perhaps most importantly, two Middle Pleistocene fossil human crania were recovered during investigations from the Museum of Anthropology, University of Athens Medical School, in the late 1970s and 1980s, found encased in brecciated sediments in Cave A. In the past, their spatial position close to each other led to the hypothesis that they were contemporaneous early Neanderthals. It was also speculated that perhaps their deposition represented a ritual practice. Our recent comparative anatomical and direct dating analyses [1] indicated not only different taxonomic affinities – Apidima 2 representing *Homo neanderthalensis*, while Apidima 1 assigned to early *Homo sapiens* – but also a different chronology for the two specimens – Apidima 2 dating to >170 ka, while Apidima 1 to >210 ka – indicating that the specimens' final resting place was not their original place of deposition, contra previous hypotheses (e.g. [2]).

Despite these findings, some researchers continue to argue for contemporaneity and a mortuary ritual. As evidence in support of their argument, they point to the position of the crania close to each other in a 'recess of the cave wall'; the absence of other remains, faunal or cultural, in the surrounding breccia matrix; the absence of associated human remains and the pattern of fragmentation of the crania; their reported association with three beach pebbles; and the red color of the surrounding sediment as arguments supporting this hypothesis [3-4]. Here we examine these claims and present contrasting evidence (i) from our firsthand observations of the fossil crania and the breccia sediments in which they were found, (ii) from archival material and field observations of the site itself and (iii) from the results of laser ablation U-series analyses.

We show that the fossil crania were found in a fissure on the ceiling of Cave A, not a 'recess in the cave wall'. Rather than found in isolation, they were encased in breccia sediment which also included numerous faunal remains and unidentified bone fragments found both around and within the hominin crania. No cutmarks or other past intentional anthropogenic markings can be observed on the specimens to support claims of intentional anthropogenic manipulation for ritual purposes, and their pattern of fragmentation is consistent with natural taphonomic processes. The breccia sediments are filled with rocks of various shapes and sizes, not just three beach pebbles, and their reddish color is similar to that of the sediments throughout the rest of the cave complex. Finally, our U-series analyses indicate that the two hominin crania were originally deposited in completely different geochemical environments. We conclude that, irrespective of their diverging chronology, the evidence from both the depositional environment and the specimens themselves refutes a ritualistic mortuary treatment. Rather, all lines of evidence are consistent with a secondary deposition in a cave fissure filling.

The study of the Apidima legacy collection is conducted under permit from the Hellenic Ministry of Culture under the auspices of the Norwegian Institute at Athens (ΑΔΑ: ΩΑΧ54653Π4-ΙΒΡ). We thank Prof. M. Kouloukoussa for her support. This research was funded by the European Research Council (ERC-CoG-724703, ERC-AdG-101019659) and the Deutsche Forschungsgemeinschaft (DFG FOR 2237, DFG HA 5258).

References: [1] Harvati, K., Röding, C., Bosman, A., Karakostis, F.A., Grün, R., Stringer, C., Karkanas, P., Thompson, N.C., Koutoulidis, V., Mouloupoulos, L.A., Gorgoulis, V.G., Kouloukoussa, M., 2019. Apidima Cave fossils provide earliest evidence of *Homo sapiens* in Eurasia. *Nature*. 571, 500-504. [2] Pitsios T. K., 1999. Paleoanthropological research at the cave site of Apidima and the surrounding region (South Peloponnese, Greece). *Anthropologischer Anzeiger*. 57, 1-11. [3] De Lumley, M.A., Guipert, G., De Lumley, H., Protopapa, N., Pitsios, T., 2020. Apidima 1 and Apidima 2: two neandertal skulls in the Peloponnese, Greece. *L'Anthropologie* 144, 1-41. [4] Otte, M., 2020. Apidima: expressions rituelles portées sur le traitement des crânes humains. *L'Anthropologie* 124, 102744.

Poster Presentation Number 66, Session 1, Thursday 14:00 - 15:30

## Diachronic variability in land-use strategies during the Middle to Upper Paleolithic transition at Lapa do Picareiro (Portugal)

Jonathan Haws<sup>1,2</sup>, Michael Benedetti<sup>2,3</sup>, Milena Carvalho<sup>2</sup>, João Cascalheira<sup>2</sup>, Nolan Ferar<sup>2</sup>, Grace Ellis<sup>2,4</sup>, Lukas Friedl<sup>2,5</sup>

1 - University of Louisville · 2 - ICArEHB, Universidade do Algarve · 3 - University of North Carolina Wilmington · 4 - Colorado State University · 5 – University of West Bohemia

Lapa do Picareiro has become an important reference site for the Middle and Upper Paleolithic in Portugal. The ongoing excavation has produced an intact stratigraphic sequence of about 11 m with archaeological occupation layers from the Bronze Age to Middle Paleolithic. A complete Upper Paleolithic sequence from the Aurignacian to Magdalenian occurs in a roughly 6 m thick section of the cave deposits. Several Middle Paleolithic occupations in ~3 m of sediment underlying the Upper Paleolithic

The sedimentary sequence of Picareiro contains extremely rich faunal assemblages and subtle variations in particle size and geochemistry that record changes in the climate, hydrology, and morphology of the cave environment. Age control is provided by over 100 radiocarbon dates. We use sedimentological analyses including magnetic susceptibility and clast size to link the cave deposits with global scale records of Upper Pleistocene climate from the Greenland ice cores and regional-scale ones from deep-sea cores off Portugal. Analyses of stratified lithic artifact assemblages reveal technological changes that correlate with climate and environmental shifts. Taphonomic analyses of the faunal remains inform on local paleoenvironments and human diet choice throughout the Paleolithic occupation of the cave.

Here we report new data from the Middle to Upper Paleolithic occupations that occur in a ~2m-thick part of the sequence. The lithic assemblages are small but informative because they show different technological systems and raw material use implying some variability in land-use strategies and site use during the interval. The sediments also record changes in magnetic susceptibility and clast size that correspond to paleoclimatic fluctuations in Greenland ice cores and speleothems from a nearby cave. The Late Middle Paleolithic occupations in Level JJ dated 54.7-42.5 ka cal BP encompass several Greenland Interstadials (GI13-10) and Heinrich Stadial 5. The lithic assemblages have characteristic discoidal flake production using quartzite, quartz, and some chert. Faunal exploitation was focused primarily on red deer with contributions of ibex, aurochs, and horse. The earliest Aurignacian presence dated 41.7-38.1 ka cal BP encompasses GI10 and HS 4. The lithic assemblage from Levels GG-II contains diagnostic carinated endscraper/cores and bladelets. These were predominately made from chert, but rock crystal was also selected. Level FF stands in stark contrast because the lithic assemblage is almost entirely comprised of simple flakes on quartzite and quartz. This layer is characterized by organic-rich, dark brown sediment that formed during the warm interval of GI8. Subsequent Aurignacian occupations in Levels DD and BB dated between ~37-34 ka cal BP are based primarily on large flake production on chert with very few bladelets. Faunal analyses from the Aurignacian levels show primary emphasis on red deer with some ibex and rabbit exploitation. This general stability in animal exploitation likely reflects the ecological flexibility of animal populations. The contrast between shifts in lithic technological organization and raw material preference and subsistence organization suggests changing land use strategies across the MUPT with some inherent ecological resilience in animal communities. Synchronicity with abrupt climate shifts suggests climate played some role in technological organization but other social factors and demography were important elements of land-use strategies.

The work at Lapa do Picareiro is funded by U.S. National Science Foundation (NSF) awards to Jonathan Haws (BCS-1420299, BCS-1724997, BCS-2150625) and Michael Benedetti (BCS-1420453, BCS-1725015, BCS-2150662). Lukas Friedl was supported by an SGS grant from the University of West Bohemia in Pilsen (SGS-2024-012). Milena Carvalho is currently a beneficiary of a CEEC – 5th Edition research contract promoted by the Portuguese FCT (reference: 2022. 06405.CEECIND). Nolan Ferar is funded by the Fundação para a Ciência e Tecnologia (PhD studentship 2022.13283.BD). João Cascalheira is funded by the European Union (ERC-CoG-2021, FINISTERRA, 101045506). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

Poster Presentation Number 67, Session 1, Thursday 14:00 - 15:30

## Exploring biomolecular preservation of Middle-Later Stone Age bone assemblages from Dar es-Soltan II (Morocco) using Zooarchaeology by Mass Spectrometry (ZooMS)

Raija Heikkilä<sup>1</sup>, Karen Ruebens<sup>2</sup>, Frido Welker<sup>3</sup>, Zineb Dayedaye<sup>4</sup>, Inssaf Himchi<sup>4</sup>, Rhayth Beneoutiq<sup>4</sup>, Fethi Amani<sup>4</sup>, Carlo Mologni<sup>5</sup>, Dorothea Mylopotamitaki<sup>1</sup>, Pauline Raymond<sup>1</sup>, Zeljko Rezek<sup>1</sup>, Abdelouahed Ben-Ncer<sup>4</sup>, Jean-Jacques Hublin<sup>1,6</sup>

1 - Chaire de Paléanthropologie, CIRB, Collège de France, PSL University, CNRS, Paris, France · 2 - Archaeology Proteomics Lab, Department of Archaeology, University of Reading, Reading, UK · 3 - Globe Institute, University of Copenhagen, Copenhagen, Denmark · 4 - Institut National des Sciences de l'Archéologie et du Patrimoine, Rabat, Morocco · 5 - Université Côte d'Azur, CNRS, OCA, IRD, Géoazur, Valbonne, France · 6 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

Faunal remains from Pleistocene archaeological sites are often highly fragmented, complicating traditional morphological analysis. In the last decade, Zooarchaeology by Mass Spectrometry (ZooMS) has become a standard tool to aid taxonomic identification, and discovery of new hominin fossils, primarily in temperate areas of Eurasia with good collagen preservation. Warm temperatures and humidity have an adverse effect on biomolecular preservation; however, such environments have had a central role in hominin evolution, including in North Africa where the oldest *Homo sapiens* fossils have been found [1]. Here, we present the results of the first palaeoproteomic analysis from Middle Stone Age (MSA) and Later Stone Age (LSA) layers at Dar es-Soltan II Cave on the Atlantic coast in northwest Morocco. The cave site is most notable for a number of MSA and LSA (Iberomaurusian) human remains recovered fifty years ago [2] and is part of an ongoing new excavation campaign in the region of Rabat-Témara. This study aimed to test the applicability of palaeoproteomics and to gain insights into collagen preservation in the caves of this region.

We applied ZooMS to 58 newly excavated bone and tooth fragments with varying taphonomy from the southern part of the current excavation area at Dar es-Soltan II, deriving from both MSA and LSA deposits. Of the 58 specimens analyzed, 37 (64%) were identifiable after Ambic buffer extraction [3], increasing to 40 (69%) following subsequent HCl demineralization [4]. The majority of the identified remains belong to Bovidae (n=33), represented primarily by the subfamily Alcelaphinae, but humans (n=4), birds (n=2), and rodents (n=1) could also be identified with ZooMS. To further assess biomolecular preservation, we calculated glutamine deamidation values for COL1 $\alpha$ 1 508-518 [5]. 21% of the Ambic-extracted bone samples produced results, ranging from 0 (completely deamidated) to 1 (no deamidation), indicating highly variable preservation of bone collagen across the sampled units and layers. Our results confirm the suitability of palaeoproteomics for taxonomic identification of unidentifiable bone fragments and the detection of new human remains at the site. Overall, our results highlight the potential for biomolecular studies to examine diet, subsistence, and the paleoenvironment at caves with Pleistocene deposits in the region.

The Dar es-Soltan II excavation is a joint project of the Chair of Paleoanthropology of Collège de France (Paris) and the Institut National des Sciences de l'Archéologie et du Patrimoine (Rabat). This research is funded by the Balzan Prize 2023 (Balzan Foundation, Bern & Milan).

References: [1] Hublin, J.-J., Ben-Ncer, A., Bailey, S.E., Freidline, S.E., Neubauer, S., Skinner, M.M., Bergmann, I., Le Cabec, A., Benazzi, S., Harvati, K., Gunz, P., 2017. New fossils from Jebel Irhoud, Morocco and the pan-African origin of *Homo sapiens*. *Nature*. 546, 289–292. [2] Debénath, A., 1978. Le gisement préhistorique de dar Es Soltane 2: Champ de tir de El Menzeh à Rabat, Maroc. *Bulletin d'Archéologie Marocaine*. 11, 9-15. [3] van Doorn, N.L., Hollund, H., Collins, M.J., 2011. A novel and non-destructive approach for ZooMS analysis: ammonium bicarbonate buffer extraction. *Archaeological and Anthropological Sciences*. 3, 281–289. [4] Welker, F., Hajdinjak, M., Talamo, S., Jaouen, K., Dannemann, M., David, F., Julien, M., Meyer, M., Kelso, J., Barnes, I., Brace, S., Kamminga, P., Fischer, R., Kessler, B.M., Stewart, J.R., Pääbo, S., Collins, M.J., Hublin, J.-J., 2016. Palaeoproteomic evidence identifies archaic hominins associated with the Châtelperronian at the Grotte du Renne. *Proceedings of the National Academy of Sciences*. 113, 11162–11167. [5] Wilson, J., van Doorn, N.L., Collins, M.J., 2012. Assessing the Extent of Bone Degradation Using Glutamine Deamidation in Collagen. *Analytical Chemistry*. 84, 9041–9048.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## Late Neandertal occupations at Arcy-sur-Cure (Yonne, France): insights from dental morphology

Juliette Henrion<sup>1,2</sup>, Jean-Jacques Hublin<sup>1</sup>, Bruno Maureille<sup>2</sup>

1 - Paléanthropologie, CIRB, Collège de France, Université PSL, CNRS, Paris, France · 2 - Univ. Bordeaux, CNRS, Ministry of Culture, PACEA, UMR 5199, Pessac, France

The prehistoric caves of Arcy-sur-Cure (Yonne, France) have drawn the attention of prehistorians and paleoanthropologists since André Leroi-Gourhan's 1958 attribution of Neanderthal remains to a Late Paleolithic assemblage [1]. Taxonomic, paleoproteomic, and chronological studies have primarily focused on one of the cave sites, the Grotte du Renne (e.g., [2-4]). However, the distinctiveness of Arcy-sur-Cure also lies in the distribution of numerous Neanderthal remains across a series of caves situated in close proximity to one another.

Five caves have yielded a total of 147 remains, spanning the Mousterian to Châtelperronian techno-complexes, which are re-contextualized in this study. A single tooth was recovered from the Grotte du Loup, while the Grotte du Bison yielded the highest number of dental remains (n=42/49), representing a minimum of nine individuals across all age groups. The Grotte du Renne brought 74 remains from at least nine individuals, primarily juveniles (ranging from in utero to pubescent). The Schoepflin Galerie, associated with the Grotte du Renne, revealed five remains from a minimum of three individuals. The Grotte de l'Hyène collection (n=18) represents at least six individuals, ranging from late childhood to old age. In each cave, pairings are identified from specimens attributed to the same lithostratigraphic unit, providing no evidence for post-depositional disturbance.

The dental assemblage exhibits a strong to pronounced expression of non-metric traits commonly observed in Neanderthals. In addition, a consistent idiosyncratic morphology is present on crown apices and marginal ridges (unworn teeth; n=35/48), expressed as semi-spherical depressions and grooves, respectively. These features were first identified on deciduous antimeres [5], then on the deciduous and permanent teeth from the collection, raising questions about the genetic proximity of the Neanderthal groups at Arcy-sur-Cure.

Inter-individual variation is also evident, particularly in the metric analysis of crown diameters and morphometric analysis of the premolar and molar enamel-dentine junction (EDJ), especially among specimens from the Grotte du Renne and Grotte du Bison. Second premolars and lower first molars tend to plot between Early and Late Neanderthals, independently of the lithostratigraphic attribution of the remains (i.e., Châtelperronian or Mousterian). However, three specimens fall morphometrically between the known variability of Neanderthals and anatomically modern humans. Two lower P4 from the Grotte du Renne—one from a Mousterian and one from a Châtelperronian context—display more symmetrical crown outlines, with one showing a moderately expressed distal accessory structure. Nevertheless, the Krapina specimens exhibit even greater proximity to the anatomically modern human range, suggesting a broader morphometric variability for both Late and Early Neanderthal P4s. Premolars also show extensive crown and root variability, both within and between individuals, as exemplified by the dental arches from the Grotte de l'Hyène.

We would like to thank the Régional Service of Archeology of Bourgogne-Franche-Comté (Y. Pautrat), the Musée National de Préhistoire—Les Eyzies (dir. J.-J. Cleyet-Merle and now N. Fourment), for granting access to the original remains and H. Temming (Max Planck Institute) and N. Vanderesse for the computed tomography scans (PACEA, Université de Bordeaux). We are thankful to M. Julien and M. Girard for discussions about Leroi-Gourhan's fieldwork at Arcy-sur-Cure. We are deeply grateful to C. Beauval, M. Bessou, M. Hardy, N. Vanderesse, A. Gicqueau & P.-J. Dodot for their collaboration in the study of Arcy-sur-Cure material; as well as the PhD committee from which those results are produced (S. Bailey, P. Bayle, S. El Zaatari, J.-J. Hublin, A. Le Cabec, B. Maureille, E. Pomeroy and S. Prat). This project was supported by UMR PACEA and ArScAn, funded by a CNRS MITI PhD grant (J. Henrion) and the Région Nouvelle Aquitaine scientific project ADNER (codir. P. Bayle and B. Maureille, convention no. AAPR2021-2020-11779310). This research benefited also from the scientific framework of the University of Bordeaux's IdEx 'Investments for the Future' program/GPR 'Human Past' and PACEA scientific teams 'EuraPal' and 'EvoDiBio' (and namely M. Augoyard, A. Arzelier, W. Banks, I. Crevecoeur, T. Davies, P. Gousset, A. Le Cabec, D. López Onandia, N. Martin, M. Thomas and C. Zanoli, for support and discussions).

References: [1] Leroi-Gourhan, A., 1958. Étude des restes humains fossiles provenant des Grottes d'Arcy-sur-Cure. *Annales de Paléontologie*. 44, 87–148. [2] Hublin, J.-J., Spoor, F., Braun, M., Zonneveld, F., Condemi, S., 1996. A late Neanderthal associated with Upper Palaeolithic artefacts. *Nature*. 381, 224–226. [3] Bailey, S.E., Hublin, J.-J., 2006. Dental remains from the Grotte du Renne at Arcy-sur-Cure (Yonne). *Journal of Human Evolution*. 50, 485–508. [4] Welker, F., Hajdinjak, M., Talamo, S., Jaouen, K., Dannemann, M., David, F., Julien, M., Meyer, M., Kelso, J., Barnes, I., Brace, S., Kamminga, P., Fischer, R., Kessler, B.M., Stewart, J.R., Pääbo, S., Collins, M.J., Hublin, J.-J., 2016. Palaeoproteomic evidence identifies archaic hominins associated with the Châtelperronian at the Grotte du Renne. *Proceedings of the National Academy of Sciences*. 113, 11162–11167. [5] Henrion, J., Hublin, J.-J., Maureille, B., 2023. New Neanderthal remains from the Châtelperronian-attributed layer X of the Grotte du Renne (Arcy-sur-Cure, France). *Journal of Human Evolution*. 181, 103402.

Poster Presentation Number 68, Session 1, Thursday 14:00 - 15:30

## Presenting hominin FoodWays: diet and food processing across climate frontiers

Amanda G. Henry<sup>1,2</sup>

1 Faculty of Archaeology, Leiden University · 2 - Tropical Botany, Naturalis Biodiversity Center.

Early African hominins lived in narrow bands of habitats that were limited by rainfall, temperature and net primary productivity [1]. Roughly 1.8 million years ago (Ma), *Homo erectus s.l.* was the first hominin to leave eastern and southern Africa and occupy a variety of new habitat types across Eurasia. There they were exposed to a suite of novel challenges stemming from the increased seasonality, cold temperatures, and unfamiliar resources of the higher latitudes [2].

How western Eurasian *H. erectus s.l.* overcame these challenges to occupy this new ‘climate envelope’ remains a subject of conjecture and debate. Recent research has suggested that diet is the functional link by which climatic changes influence evolutionary processes - differing temperatures and rainfall cause minimal disruption to human behavioural patterns, but climate change does affect food availability and accessibility, which has immediate and critical effects on behaviours [3]. Therefore, the expansion of a species into new climate envelopes must also entail dietary changes, with concomitant influences on evolutionary patterns. While changes in climate and their potential effect on the earliest migrations into Eurasia have been explored, the actual causal links to dietary changes have thus far been limited to a handful of studies, most of which focus on the potential importance of large game.

The most abundant potential food sources, namely the plants, algae, fungi, honey and other “sessile” items, have only occasionally considered in explanations for the expansion of *H. erectus s.l.* into Eurasia, and usually only at a small region or site rather than at the full continental scale of the migration. In contrast to animal resources that generally move freely across a number of different habitats and have a less-predictable distributions, sessile foods are fixed in time and space. This makes them more predictable within a habitat but more variable across habitats, and thus more likely to be differently used in different habitats than mobile (animal) foods. The suite of sessile foods in western Eurasia is sharply different from those in eastern and southern Africa, making their use one of the greatest changes experienced hominins migrating from this region [4]. Beyond to the important calories and nutrients provided by sessile foods, the use of food processing techniques such as fermentation or cooking may have additionally contributed to *H. erectus s.l.* success. These techniques increase the caloric value of foods by reducing the energetic costs of digestion, and can remove toxins thereby turning some inedible foods into nutritious ones [5]. Both of these factors could turn previously marginal habitats into useful ones. However, evidence for fire use and fermentation remains elusive in the archaeological record for this period.

This project, recently funded by the Dutch Research Council, proposes that sessile foods and food processing provided key advantages that allowed *H. erectus s.l.* to overcome the climate constraints that affected earlier taxa. We will collect data on the visibility of these foods and processing techniques in dental calculus, and explore if they are present in archaeological specimens. Furthermore, we will explore the energetic costs of collecting and processing sessile foods, as well as new data on the nutritional properties of these foods, and combine these data with habitat reconstructions in order to create detailed “nutritional landscapes”. Using agent-based modeling we will then investigate which novel dietary behaviours enabled *H. erectus* to expand into the new habitats of western Eurasia, and to compare how well these dietary behaviours explain the patterns of *H. erectus s.l.* occupations, in contrast to other proposed key changes, such as new technologies or new social networks.

References: [1] Timmermann, A., Yun, K.-S., Raia, P., Ruan, J., Mondanaro, A., Zeller, E., Zollikofer, C., Ponce de León, M., Lemmon, D., Willeit, M., Ganopolski, A., 2022. Climate effects on archaic human habitats and species successions. *Nature*. 604, 495–501. [2] Hosfield, R., 2016. Walking in a Winter Wonderland? Strategies for Early and Middle Pleistocene Survival in Midlatitude Europe. *Current Anthropology*. 57, 653–682. [3] Marean, C.W., Anderson, R.J., Bar-Matthews, M., Braun, K., Cawthra, H.C., Cowling, R.M., Engelbrecht, F., Esler, K.J., Fisher, E., Franklin, J., Hill, K., Janssen, M., Potts, A.J., Zahn, R., 2015. A new research strategy for integrating studies of paleoclimate, paleoenvironment, and paleoanthropology. *Evolutionary Anthropology: Issues, News, and Reviews*. 24, 62–72. [4] Jones, M. (2009). Moving North: Archaeobotanical Evidence for Plant Diet in Middle and Upper Paleolithic Europe. In: Hublin, J.J., Richards, M.P. (Eds) *The Evolution of Hominin Diets, Vertebrate Paleobiology and Paleoanthropology*, Springer, Dordrecht. [5] Wrangham, R., 2017. Control of Fire in the Paleolithic. *Current Anthropology*. 58, S303–S313.

Poster Presentation Number 69, Session 1, Thursday 14:00 - 15:30

## Eemian Neanderthal reloaded: Resson calcareous tufa sequence (Aube, France) and the rediscovery of Eemian human settlement in Northwest Europe

David Hérissou<sup>1</sup>, Julie Dabkowski<sup>2</sup>, Nelson Ahmed-Delacroix<sup>1,3</sup>, Pierre Antoine<sup>2</sup>, Benjamin Audiard<sup>1</sup>, Jean-Jacques Bahain<sup>4</sup>, Léa Beaumont<sup>2</sup>, Christophe Falguères<sup>4</sup>, Ghislain Grégoire<sup>5</sup>, Guillaume Jamet<sup>2,3</sup>, Marie-Claude Jolly-Saad<sup>1</sup>, Loïc Lebreton<sup>6</sup>, Jean-Luc Lochet<sup>2,3</sup>, Nicole Limondin-Lozouet<sup>2</sup>, Eva Sambourg<sup>2</sup>, Noémie Sévère<sup>7,8</sup>, Olivier Tombret<sup>4</sup>, Amélie Violet<sup>4</sup>

1 - CNRS-UMR7041 ArScAn · 2 - CNRS-UMR8591 LGP · 3 - INRAP · 4 - MNHN; CNRS-UMR7194 HNHP, UPVD · 5 - Musée Saint-Loup de Troyes · 6 - CNRS-UMR7269 LAMPEA · 7 - Géoarchéon · 8 - CNRS-UMR7044 Archimède

In the late 1980s, C. Gamble [1] initiated a debate on the capacity of early hominins to colonise the northern latitudes of Europe during the Middle and Late Pleistocene interglacial periods. At that time, the Last Interglacial (Eemian; MIS 5e) was characterised by a total absence of human occupation in Northern France, Belgium, Netherlands, Germany and Great Britain. Since the 1990s, a few sites with evidence of human occupation attributed to the Eemian have been re-evaluated, discovered and excavated in Central and Middle Europe, particularly in Germany. Subsequent to these discoveries, a number of authors, including Roebroeks et al. [2], have rejected Gamble's model. In 2006, a series of Middle Palaeolithic levels were unearthed at the base of the Caours Eemian tufa (Somme basin) in northern France [3]. This initial documentation of human presence during the Last Interglacial in northwestern Europe inaugurates a novel research paradigm, centring on the capacity of Neanderthal communities to inhabit the dense forest ecosystems of the Eemian period. In 2013, a new Eemian sequence with human occupations was discovered in Waziers (North, France) [4]. Five archaeological layers were identified in fluvial deposits and peat layers, which exhibited a correlation extending from the termination of MIS 6 through to the first half of MIS 5e.

In 2020, a new research programme was initiated with the objective of revisiting the Resson site, showing a sequence of calcareous tufa that we supposed to be coeval with Eemian period [5]. This substantial tufa massif (>10 m thick), which is located in the geographical confines of Aube (France), were previously described on sporadic occasions, by i.e. Leymerie (1846) or Fliche (1883). Leymerie reported the presence of leaf impressions and faunal remains typical of interglacial periods, and Fliche described faunal remains with anthropic traces (cutting marks) associated with a flint le Moustier-type spear and mentioned the presence of Neanderthal remain fragments. It is unfortunate that these elements do not have precise geographical and stratigraphic localisations. We reopened an abandoned tufa quarry of the massif in 2020, another abandoned quarry in 2022 and carried out 7 deep test pits between the two quarries coupled with geophysical prospection. A test excavation was carried out in the second quarry in 2024. The tufaceous sequence was analysed using a multi-proxy approach, confirming its attribution to the Eemian interglacial. The Pleistocene sequence of more than 10 meters in the first quarry begins at the end of MIS 6 and ends after the Eemian Optimum (located at a height of nearly 8 m). At least three archaeological levels have been identified in the first quarry and four in the second. Local flint was used to produce flakes and points, thanks to the Levallois and discoid concepts. Some of them show traces of anthropic activity. After 5 years, the recent research programme has allowed to approve the archaeological status of the Resson site and to document a reference sequence for the Eemian in North-West Europe.

In this presentation, the scientific context, questions and issues surrounding the human presence or absence in dense forest environments during the Eemian period will be outlined. The presentation will showcase recent discoveries that have led to a paradigm shift in the field, challenging established models of human settlement dynamics and adaptation capacities established during the 1990s. Subsequently, the unpublished results of the recent excavations at Resson and the re-evaluation of the ancient discoveries will be presented. The Eemian Neanderthal is reloaded and a new face is revealed, in which Resson is a rare and fruitful facet.

References: [1] Gamble, C., 1986. *The Palaeolithic Settlement of Europe*. Cambridge University Press. [2] Roebroeks, W., Conard, N.J., van Kolfschoten, T., Dennell, R.W., Dunnell, R.C., Gamble, C., Graves, P., Jacobs, K., Otte, M., Roc, D., Svoboda, J., Tuffreau, A., Voytek, B.A., Wenban-Smith, F., Wymer, J.J., 1992. Dense Forests, Cold Steppes, and the Palaeolithic Settlement of Northern Europe [and Comments and Replies]. *Current Anthropology*. 33, 551–586. [3] Antoine, P., Limondin-Lozouet, N., Dabkowski, J., Bahain, J., Ghaleb, B., Reyss, J., Auguste, P., Sévère, N., Jamet, G., Jolly-Saad, M., Gauthier, A., Lebreton, L., Lochet, J., 2024. Last interglacial in western Europe: 20 years of multidisciplinary research on the Eemian (MIS 5e) calcareous tufa sequence at Caours (Somme basin, France) – a review. *Boreas*. 53, 297–346. [4] Quaternaire, 2022. Volume 33, Issue 4. *Revue de l'Association française pour l'étude du Quaternaire*. <https://doi.org/10.4000/quaternaire.17129> [5] Dabkowski, J., Limondin-Lozouet, N., Jolly-Saad, M., 2020. Données paléoenvironnementales et biostratigraphiques du tuf de Resson (Aube, France): révision d'un enregistrement eemien. *Quaternaire*. 133–144.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## From bones to blood to brains: a comparative analysis of the carotid canal in South African fossil hominins

Harmony Rose Hill<sup>1</sup>, Douglas Momberg<sup>2</sup>, Jean-Pierre Tassu<sup>3</sup>, Franck Guy<sup>1</sup>, Jérôme Surault<sup>1</sup>, Bernhard Zipfel<sup>4</sup>, Dominic Stratford<sup>5,6</sup>, Amélie Beaudet<sup>1,5,7</sup>

1 - Laboratoire de Paléontologie, Évolution, Paléoécosystèmes et Paléoprimatologie (PALEVOPRIM), UMR 7262 CNRS & Université de Poitiers, France · 2 - SAMRC/Wits Developmental Pathways for Health Research Unit, Department of Paediatrics and Child Health, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, South Africa · 3 - Centre Hospitalier Universitaire de Poitiers, France · 4 - Evolutionary Studies Institute, University of the Witwatersrand, South Africa · 5 - School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, South Africa · 6 - Stony Brook University, Stony Brook, New York, USA · 7 - Department of Archaeology, University of Cambridge, United Kingdom

Is it possible to track changes in cerebral blood flow and, by extension, cerebral metabolism in the fossil hominin lineage? If so, this may confer valuable insight into the timing and nature of the environmental factors underlying shifts in hominin brain size, shape, organisation and ontogeny and their implication in the emergence of modern human cognitive capacities and behaviours. Yet without soft tissues, osteological proxies for cerebral vascularisation are our only evidentiary source in this pursuit. Previous research has demonstrated that in hominids, the size of the carotid canals, located in the petrous temporal bones, reliably predict both the size of the internal carotid arteries (which account for 75-85% of brain perfusion) and glucose consumption [1,2]. In this context, our study aims to quantitatively investigate variation in carotid canal size amongst South African fossil hominins. By controlling for taxonomic and geographical context, we expect to be able to detect inter-specific and time-related changes in brain perfusion and glucose consumption. We focus namely on three taxa (*Australopithecus africanus*, *Paranthropus robustus* and *Homo naledi*) which collectively span over three million years, a brain size range of 363-595cc and a large spectrum of brain (re)organisation [3,4].

Our sample included adult fossil specimens from *A. africanus* (N=9), *P. robustus* (N=3) and *H. naledi* (N=2) stored in the collections of the University of the Witwatersrand and the Ditsong National Museum of Natural History (South Africa), as well as complete adult crania from extant chimpanzees (N=10) and extant humans (N=8), which were respectively sourced from the Smithsonian Museum of Natural History (USA) and Royal Museum of Central Africa (Belgium) repositories available on Morphosource and the Pretoria Bone Collection (South Africa). Every specimen was visualised as a 3D model using 3D Slicer 5.4.0. Using the closed curve markup, control points were manually placed around the border of each canal opening. Each curve, resampled to 15 control points, was projected onto a best-fit plane using singular value decomposition. Surface area inside the curve was then extracted and measured.

Mean external carotid canal opening area was highest in extant humans (34.3 mm<sup>2</sup>) and *H. naledi* (23.0 mm<sup>2</sup>) and slightly higher in extant chimpanzees (20.5 mm<sup>2</sup>) than *Paranthropus* (18.2 mm<sup>2</sup>) and *Australopithecus* (15.5 mm<sup>2</sup>). Ranges for both extant humans (16.9-50.7 mm<sup>2</sup>) and extant chimpanzees (13-31.5 mm<sup>2</sup>) were expansive, though maximum and minimum measurements were notably higher in humans. Most values for all three hominin taxa lay within both human and chimpanzee ranges; however, the lowest values for both *Paranthropus* and *Australopithecus* fell below even the chimpanzee range. Interestingly, the *Paranthropus* specimen from Swartkrans exhibited an area less than half of those from Drimolen.

Our results regarding early hominin carotid canal dimensions are consistent with previous findings [1] that blood flow rates in *Australopithecus* are lower than in non-human apes, despite comparable brain volumes [5]. Overlap between *Australopithecus* and *Paranthropus* ranges is consistent with their brain sizes and level of cortical reorganisation [4]. The fact that values for *H. naledi* fall within the range of human variation [2] whilst its cranial capacities lie firmly within australopithecine range suggests factors beyond brain size, for example the energetic cost of derived brain organisation [3], shaped neuro-vascular morphology. To gain a fuller picture of the evolution of brain perfusion, osteological proxies for the vertebral arteries, which supply 15-25% of cerebral perfusion, are also being measured using this method. Moreover, ongoing work will integrate both East African hominin fossils and a larger comparative human/chimpanzee sample with a view to refining our appreciation of extinct and extant variation patterns.

We would like to thank staff and curators at the Ditsong National Museum of Natural History as well as at the Evolutionary Science Institute (ESI) of the University of the Witwatersrand for their generous permission and support in scanning and digitising the fossil sample. For provision of the extant sample, our gratitude also goes to the Pretoria Bone Collection, as well as to the Smithsonian Museum of Natural History and Royal Museum of Central Africa for their uploading of open-access chimpanzee cranial meshes to Morphosource. This project has received financial support from the CNRS through the MITI interdisciplinary program "Jumeaux Numériques" and the Chaire Professeure Junior Hominines.

References: [1] Seymour, R.S., Bosiocic, V., Snelling, E.P., 2016. Fossil skulls reveal that blood flow rate to the brain increased faster than brain volume during human evolution. *Royal Society Open Science*. 3, 160305. [2] Boyer, D.M., Harrington, A.R., 2019. New estimates of blood flow rates in the vertebral artery of eurafrican hominins and their implications for encephalic blood flow scaling: A response to Seymour and Snelling (2018). *Journal of Human Evolution*. 128, 93–98. [3] Holloway, R.L., Hurst, S.D., Garvin, H.M., Schoenemann, P.T., Vanti, W.B., Berger, L.R., Hawks, J., 2018. Endocranial morphology of *Homo naledi* from the Dinaledi Chamber, South Africa. *Proceedings of the National Academy of Sciences*. 115, 5738–5743. [4] Beaudet, A., Clarke, R.J., de Jager, E.J., Bruxelles, L., Carlson, K.J., Crompton, R., de Beer, F., Dhaene, J., Heaton, J.L., Jakata, K., Jashashvili, T., Kuman, K., McClymont, J., Pickering, T.R., Stratford, D., 2019. The endocranial of StW 573 ("Little Foot") and

hominin brain evolution. *Journal of Human Evolution*. 126, 112–123. [5] Seymour, R.S., Bosiocic, V., Snelling, E.P., Chikezie, P.C., Hu, Q., Nelson, T.J., Zipfel, B., Miller, C.V., 2019. Cerebral blood flow rates in recent great apes are greater than in *Australopithecus* species that had equal or larger brains. *Proceedings of the Royal Society B: Biological Sciences*. 286, 20192208.

Poster Presentation Number 70, Session 1, Thursday 14:00 - 15:30

## **The lithic assemblage and use-wear from the recent excavations of Shanidar Cave, Iraqi-Kurdistan: a preliminary perspective**

**Michael Hitchcock<sup>1</sup>, Chris Hunt<sup>1</sup>, Tim Reynolds<sup>2</sup>, Graeme Barker<sup>3</sup>**

1 - Liverpool John Moores University · 2 - Birkbeck, University of London · 3 - University of Cambridge

Shanidar Cave is among the most significant Neanderthal sites. Excavations by Ralph Solecki in the 1950s unearthed ten Neanderthals and have played a crucial role in our understanding of Neanderthal behaviour and stone tools attributed to the Mousterian. Solecki identified a hiatus of about a metre above the Mousterian, followed by deposits with Upper Palaeolithic Baradostian material culture, broadly equivalent to the Aurignacian. Further excavations have further developed our understanding of the cave's occupants.

The recent excavations used single-context excavation, with three-dimensional plotting of all artefacts bigger than 2 cm. Over 1000 lithics were identified and attributed to typological class. The results show that there is a degree of overlap between typologically Mousterian and Baradostian artefacts with no clear hiatus between them. Tool forms not typically associated with Neanderthals such as bladelets and blades were recovered from secure contexts in the later part of MIS 5a, some of which also preserved the skeletal remains of Neanderthals.

Use-wear analysis showed that 107 lithics retain evidence of use. The materials worked include wood, bone and hide, as well as general butchery activities and occasional working of plants. Applying the location of tools worked against the site's Harris Matrix has revealed changes in the use of materials within the site. Bone working is rare in the earlier contexts but becomes common later. The opposite is true for woodworking for which there is a high degree of evidence in the Neanderthal-associated contexts. Hide working and butchery remain similar throughout the sequence. Use-wear was conducted using a Dino-Lite Edge digital microscope and a comparative reference collection.

Our results show that the typical application of an industry to a hominin group may not be easily applicable at Shanidar. Further, changes in worked materials through the site's sequence hint at a change in non-lithic tools from wood in MIS 5a to bone in MIS 3.

The Authors acknowledge HM Govt of Gibraltar, the Professional Aid Guild and the John Mackintosh Educational Trust for their contributions to funding this study.

Podium Presentation, Session 10, Saturday 15:50 – 17:10

## The age and environment of the Taung child

Philip J. Hopley<sup>1,2</sup>, Pieter Vermeesch<sup>2</sup>, Hank Sombroek<sup>1</sup>, Randall Parrish<sup>3</sup>

1 - Birkbeck, University of London · 2 - University College London · 3 - University of Portsmouth

Since the discovery of the Taung Child in 1924 the age and environment of the Taung Type Site, and of *Australopithecus africanus* more broadly, has been debated. The current consensus age estimate for the fossil is approximately 2.8 to 2.0 Ma based on biostratigraphic inference [1]. In the centenary year of Raymond Dart's seminal publication on Taung [2], we are able to present the first radiometric date for the Taung Child and to make new reconstructions of the depositional environment at the site. We outline different approaches to flowstone U-Pb age determination and demonstrate that, in this instance, the most accurate age is produced using the often-overlooked <sup>207</sup>Pb–<sup>235</sup>U chronometer. A flowstone (IDPH14) is amongst the youngest sediments from the site and dates to the Late Pliocene ( $2.98 \pm 0.06$  Ma). Unfortunately, dating efforts lower in the stratigraphic sequence have been unsuccessful, so we cannot currently bracket the age of the fossil. However, at >3.0 Ma the age of *A. africanus* is pushed back firmly into the Pliocene and is comparable with cosmogenic nuclide dating for *A. africanus* from Sterkfontein [3] and the age of australopithecines from eastern Africa. We will discuss how our dating approach raises questions about the accuracy of published disequilibrium corrected <sup>206</sup>Pb–<sup>238</sup>U ages from South African hominin sites [4]. We also present the results from >50 m of sediment cores at Taung that detail the microbial and floral communities present within tufa barrages and cascades, seasonal wetlands and palustrine environments; including cave formation as the final phase of landscape evolution. We outline how an understanding of this dynamic sedimentary environment builds a detailed picture of hominin palaeoecology at Taung. We are also able to confirm preliminary evidence [5] that the Taung Child was accumulated on the palaeo-landsurface and not in a cave environment, as previously thought.

References: [1] Frost, S.R., White, F.J., Reda, H.G., Gilbert, C.C., 2022. Biochronology of South African hominin-bearing sites: A reassessment using cercopithecoid primates. *Proceedings of the National Academy of Sciences*. 119. [2] Dart, R.A., 1925. *Australopithecus africanus*: The Man-Ape of South Africa. *Nature*. 115, 195–199. [3] Granger, D.E., Stratford, D., Bruxelles, L., Gibbon, R.J., Clarke, R.J., Kuman, K., 2022. Cosmogenic nuclide dating of *Australopithecus* at Sterkfontein, South Africa. *Proceedings of the National Academy of Sciences*. 119. [4] Pickering, R., Herries, A.I.R., Woodhead, J.D., Hellstrom, J.C., Green, H.E., Paul, B., Ritzman, T., Strait, D.S., Schoville, B.J., Hancox, P.J., 2018. U–Pb-dated flowstones restrict South African early hominin record to dry climate phases. *Nature*. 565, 226–229. [5] Hopley, P.J., Herries, A.I.R., Baker, S.E., Kuhn, B.F., Menter, C.G., 2013. Brief Communication: Beyond the South African cave paradigm—*Australopithecus africanus* from Plio–Pleistocene paleosol deposits at Taung. *American Journal of Physical Anthropology*. 151, 316–324.

Poster Presentation Number 71, Session 1, Thursday 14:00 - 15:30

## Evolutionary drivers of encephalization and facial reduction in the genus *Homo*

Mark Hubbe<sup>1,3</sup>, Katerina Harvati<sup>2,3</sup>

1 - Department of Anthropology, Ohio State University · 2 - Paleoanthropology, Institute for Archaeological Sciences and Senckenberg Center for Human Evolution and Paleoenvironment, Eberhard Karls University of Tübingen · 3 - DFG Centre for Advanced Studies 'Words, Bones, Genes, Tools: Tracking Linguistic, Cultural and Biological Trajectories of the Human Past'

The evolution of the cranial morphology of the genus *Homo* is marked by a general tendency towards increased encephalization and reduced facial and dental robusticity. These physical changes culminated in the Middle to Late Pleistocene and were accompanied by important behavioral changes, including reliance on stone tool use, a diversification of subsistence, and geographic range expansions. It is generally assumed that these behavioral changes were enabled over time by selection for greater cognitive abilities, correlating with increased encephalization. At the same time these changes have been hypothesized as strong directional selection pressures for decreasing facial and dental size to reduce energetic costs. Here, we test the commonly assumed hypothesis that directional selection drove increased encephalization and reduced facial size through time, by exploring the fit of different evolutionary processes – directional selection, stabilizing selection, neutral evolution, punctuated equilibrium – to human cranial morphological variation within the genus *Homo*.

Our sample includes three-dimensional coordinates of neurocrania and faces of 62 fossil *Homo* and 24 recent *Homo sapiens*, grouped into eight Operational Taxonomic Units. Principal Components Analyses (PCA), conducted on Procrustes superimposed coordinates were used as linear dimensions of morphological change for two lineages in the genus: one leading to *Homo sapiens*, the other leading to Neandertals. For each anatomical region, the fit of six evolutionary scenarios were tested.

The analyses of the neurocranium showed strongest support for models of neutral evolution (Unbiased Random Walk) and strict stasis across the different PCs for the *Homo sapiens* lineage, and strongest support for neutral evolution (Unbiased Random Walk), stasis, strict stasis across the different PCs for the Neandertal lineage. These results reject the hypothesis of isotonic directional selection driving the evolution of encephalization. The analyses of the face showed strongest support for models of stasis and strict stasis across the different PCs for the *Homo sapiens* lineage, and strongest support for strict stasis and neutral evolution (Unbiased Random Walk) across the different PCs for the Neandertal lineage. These results reject the hypothesis that the reduction of facial dimensions is responding to constant directional selection along the genus *Homo*.

In conclusion, our results are consistent with previous work suggesting a limited role for directional selection in human evolution and underscore the importance of stabilizing selection and constraints, which our analyses overwhelmingly supported relative to other evolutionary processes. They also suggest that during critical transitions in the history of the genus *Homo*, the release of stabilizing selection, likely enabled through the increased importance of cultural behaviors, played a transformative role, enabling other evolutionary processes to take hold.

Poster Presentation Number 2 Session 1, Thursday 14:00 - 15:30

## The temporal pneumatization in Middle and Late Pleistocene hominins from China

Jiaming Hui<sup>1</sup>, Xuan Zhang<sup>1</sup>, Xiujie Wu<sup>1</sup>, Antoine Balzeau<sup>2,3</sup>

1 - Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China · 2 - PaleoFED team, UMR 7194 Histoire Naturelle des humanités Préhistoriques, MNHN-CNRS-UPVD, Paris, France · 3 - Department of African Zoology, Royal Museum for Central Africa, Tervuren, Belgium

Temporal pneumatization is a trait widely shared within hominids. While some consider temporal pneumatization a functional adaptation to environmental factors, some notice that its development is related to the temporal bone and endocranial morphology [1]. In other words, hominins with different cranial morphology may present variable levels of pneumatization, which indicates the potential taxonomic significance of this trait. However, the evolutionary trajectory of temporal pneumatization is not clear, which has hindered its interpretation.

Previous studies revealed that the temporal bones are strongly pneumatized in apes, as the air-filled cells can spread almost all over the bone. The ape-like pattern manifests in some early hominins, including some *Australopithecus* and *Paranthropus* species. In contrast, *Homo* generally possesses reduced pneumatization [2]. Still, intra- and inter-species variations can also be found in *Homo*. Zhoukoudian *Homo erectus* manifests rather developed temporal cells, which extends from the mastoid into the squama, petrous area, and articular tubercle. This pattern is different from Java *Homo erectus*. Besides, *Homo neanderthalensis* tend to manifest a reduced pneumatization constrained within the petromastoid part, with a lower extension and less intra-species variation than that in *Homo sapiens* [3].

Nevertheless, the temporal pneumatization of many other hominin groups are still largely unexplored. Apart from Zhoukoudian *Homo erectus*, the temporal pneumatization in most Chinese fossils have not been recorded. It is unknown whether other Chinese *Homo erectus* fossils manifest the special pattern found in Zhoukoudian. Moreover, several Chinese fossils (e.g., Xuchang and Xujiayao) show some Neanderthal-like cranial features [4], but it is unknown whether they may also present a Neanderthal-like pneumatization. Here, our study reconstructed the temporal cells of eight Chinese hominins from the Middle and Late Pleistocene, including Dali, Hexian, Xuchang, Xujiayao, Yahuaidong, Liujiang, Qihedong, and Ziyang. Using the Micro-CT data of these fossils, we manually segmented the temporal cells. The comparative data are from the published models and illustrations, including apes, *Australopithecus*, *Paranthropus*, *Homo erectus*, *Homo neanderthalensis*, and extant humans.

The result shows the temporal pneumatization in Hexian *Homo erectus* is highly developed. The cells extend into the centre of the squama and zygomatic process. This feature is similar to that in Zhoukoudian but differs from those in Java. It is thus reasonable to hypothesize that a developed pattern may be a feature of Chinese *Homo erectus*, which is archaic and similar to many early hominins. In Dali cranium, the temporal pneumatization is much more reduced than that in Chinese *Homo erectus*. Its temporal cells are limited in the mastoid and petrous parts. The same pattern appears in Xuchang, while Xujiayao, another specimen assigned to *Homo juluensis* together with Xuchang, shows a more developed level. The cells in Xujiayao extend anterosuperiorly into the squama and approach the zygomatic process. This pattern is different from that in most *Homo neanderthalensis*. Finally, in the *Homo sapiens* sample, variations are also detected. Liujiang possesses the smallest pneumatization, as its cells only appear in the lower part of the mastoid part. Meanwhile, in Yahuaidong, Qihedong, and Ziyang, the cells are mainly distributed in the mastoid and petrous, with few cells extending into or towards the zygomatic process and squama. Generally, this study reveals the diversity in temporal pneumatization among Asian hominins, indicating a noticeable intra-species variability. Together with more data of Asian fossils records from future studies, this study will contribute to a better understanding of this trait.

This study was funded by the National Key Research and Development program of China (2023YFF0804502), National Natural Science Foundation of China (42372001, 42472006), and the French National Research Agency (ANR-20-CE27-0009).

References: [1] Balzeau, A., Grimaud-Hervé, D., 2006. Cranial base morphology and temporal bone pneumatization in Asian *Homo erectus*. *Journal of Human Evolution*. 51, 350–359. [2] Sherwood RJ, 1995. The hominid temporal bone: ontogeny and phylogenetic implications. Ph.D. Dissertation, Kent State University, USA. [3] Balzeau, A., Radović, J., 2008. Variation and modalities of growth and development of the temporal bone pneumatization in Neandertals. *Journal of Human Evolution*. 54, 546–567. [4] Li, Z.-Y., Wu, X.-J., Zhou, L.-P., Liu, W., Gao, X., Nian, X.-M., Trinkaus, E., 2017. Late Pleistocene archaic human crania from Xuchang, China. *Science*. 355, 969–972.

Podium Presentation, Session 1, Thursday 09:20 – 11:00

## Site formation and Neanderthal deposition at Shanidar Cave, Iraq

Chris Hunt<sup>1</sup>, Duncan Pirrie<sup>2</sup>, Emma Pomeroy<sup>3</sup>, Ingrid Ward<sup>4</sup>, James Holman<sup>5</sup>, Tim Reynolds<sup>6</sup>, Graeme Barker<sup>7</sup>

1 - Liverpool John Moores University · 2 - University of South Wales, Helford Geosciences · 3 - University of Cambridge · 4 - Perth · 5 - Canterbury Archaeological Trust · 6 - Birkbeck, University of London · 7 - University of Cambridge

Shanidar Cave, Iraqi Kurdistan, is renowned as the locality where Ralph Solecki recovered skeletal material from ten Neanderthals [1]. Our re-excavation has yielded further elements from Shanidar 5 and parts of three Neanderthals from the Shanidar 4 cluster. Here we describe the processes of site formation of the 11 m sedimentary sequence exposed during the re-excavation of Solecki's trench. We discuss the contexts of the Neanderthal skeletal material and what these tell us about Solecki's suggestions of Neanderthal burial.

The bulk of the re-exposed sequence in the Solecki trench is largely more-or-less lenticular layers of fine silty sands and sandy silts, sometimes crudely laminated, with varying admixtures of mostly subangular limestone gravel, probably originating from hypercritical flows and shallow sheet-wash. These sediments are punctuated by lenticular and sheetlike sandy gravels suggesting unconfined shallow flows, and by occasional breccia layers rich in boulders and resulting from rockfall and debris-avalanche. Various degrees of pedogenic/diagenetic alteration are visible throughout. The Palaeolithic sequence lies chronologically between the top of MIS 5b and the upper part of MIS 3.

Sedimentation was controlled by topography, sediment source and depositional mechanism. Inputs from the dolomitic country rock included boulders and breccia from rock-fall, sand from granular disintegration and fine silts and clays from dissolution. Rock-fall was concentrated near the cave mouth and along the line of an adjacent episodically-active fault. Coarse silt/very fine sand seems to have arrived mostly by aeolian input from dust storms originating in the Arabian Peninsula, and at times from glacierised terrain to the north and east. Ephemeral vadose flows, originating upstream in the gorge, laid down sandy gravels in shallow streamways originating from rifts in the eastern side of the cave. Pedogenesis likely reflects episodes of relatively temperate palaeoclimate. It is marked by root channels, jointing and ped-like aggregates sometimes with weak clay skins, manganese mottles, calc nodule and plugged calcrete horizons.

The Neanderthal skeletal material is associated with layers showing significant pedogenesis. Shanidar 5 and 3 were disturbed by mudflows, in both cases before full skeletonization. Shanidar 2 had also been disturbed and gnawed by rodents but parts were still in articulation. The skull of Shanidar 1 was probably manipulated after skeletonization because the mandible was placed beside the cranium and some neck vertebrae, detached from the rest of the skeleton. Solecki recorded a pile of stones over this individual. Bodies of the Shanidar 4 cluster were placed episodically in an aggrading gully, immediately adjacent to a 3 m high boulder. There is mineralisation below Shanidar Z and A, suggesting decay of the bodies in-situ: mineralisation was also recorded by Solecki around the bones of Shanidar 4 but of uncertain significance. The location of the Shanidar 7 baby in the Solecki excavation is consistent with it having been placed in another gully to the north of the Shanidar 4 cluster.

The word 'deposition' implies some sort of purposeful and systematic disposal of the dead. Solecki's writings in the early 1960s are broadly consistent in the notion that the Shanidar Neanderthals were the victims of rockfalls or similar catastrophes, though he argued that Shanidar 1 was later purposely covered with a cairn. The discovery of the pollen clumps associated with Shanidar 4 and the coining of the 'Flower Burial' hypothesis brought his ideas of Neanderthal funerary behaviour to a new level. The disruption of Shanidar 2,3 and 5 by natural processes precludes any judgement being made in these cases but we now seem to have evidence for purposeful mortuary behaviour with the Shanidar 4 cluster, Shanidar 1 and conceivably Shanidar 7. The theory of burial with flowers can, however, be discounted.

We thank the Kurdistan Regional Government and the Kurdistan Directorate of Antiquities for permission to re-excavate and for their support in the field and especially their directors, Mala Awat and Kaifi Mustafa Ali. We thank the Director of the Soran Directorate of Antiquities, Dr Abdulwahab Suleiman, and the on-site Representatives of the Directorate Dîshad Adulmutalb, Jeghir Khalil and Sherzad Hassan for their logistical support and work with the Shanidar Cave Project. We thank the Leverhulme Trust (Research Grant RPG-2013-105 and Emeritus Fellowship EM-2025-081), John Templeton Foundation, Rust Family Foundation, McDonald Institute for Archaeological Research, the Society of Antiquaries, the Wenner Grenn Foundation, the British Academy, the Leakey Foundation and Liverpool John Moores University for their support of excavations and analyses by the Shanidar Cave Project.

References: [1] Solecki, R.S., 1971. Shanidar: The First Flower People, Knopf, Inc., New York.

Poster Presentation Number 72, Session 1, Thursday 14:00 - 15:30

## Modern human carpal morphology evolved late in the hominin lineage from an African ape-like carpus

Laura E. Hunter<sup>1</sup>, Matthew W. Tocheri<sup>2,3,4</sup>, Caley M. Orr<sup>5,6</sup>, Biren A. Patel<sup>7,8</sup>, Zeresenay Alemseged<sup>1</sup>

1 - Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL · 2 - Human Origins Program, National Museum of Natural History, Smithsonian Institution, Washington, DC · 3 - Department of Anthropology, Lakehead University, Thunder Bay, ON, Canada · 4 - Australian Research Council, Centre of Excellence for Australian Biodiversity and Heritage, Wollongong University, Wollongong, New South Wales, Australia · 5 - Department of Cell and Developmental Biology, University of Colorado School of Medicine, Aurora, CO · 6 - Department of Anthropology, University of Colorado Denver, Denver, CO, Division of Integrative Anatomical Sciences · 7 - Department of Medical Education, Keck School of Medicine, University of Southern California, Los Angeles, CA, Human and Evolutionary Biology Section · 8 - Department of Biological Sciences, University of Southern California, Los Angeles, CA

The evolutionary history of the human lineage is characterized through time by a decreased reliance on use of the forelimb for weight-bearing locomotor tasks and increased reliance on the hand for manipulation. However, the habitual hand functions of fossil hominins and their common ancestor with African apes are debated. Wrist kinematics dictates hand posture; therefore, carpal morphology is central to inferring forelimb use in extinct hominines. Carpal shapes, however, are extremely challenging to quantify due to their irregular shapes and this has led to a limited number of comprehensive studies relative to other parts of the postcranial skeleton. Here, we analyze overall carpal morphology from a broad sample of anthropoids, including many fossil hominins, using a specialized three-dimensional method called spherical harmonics. We further use hierarchical clustering and classification methods to characterize and categorize hominin fossils based on their morphological shape similarities with extant taxa. Results show that hominin carpals, particularly the lunate and triquetrum, closely resemble those of African apes. Derived features of the human capitate, scaphoid, and trapezoid appear to have evolved from features widely considered hominine synapomorphies. The morphofunctional features of hominin wrist bones show striking variability as early as *Australopithecus afarensis* that persist as late as *Homo naledi*, suggesting early relaxed selection, followed by stabilizing selection for modern human-like morphology that emerges only in later *Homo* and thus likely associated with recent manipulatory behaviors. These results indicate that the hominin carpus evolved from an African ape-like wrist towards a modern human-like wrist, with rapid radial-side reorganization occurring relatively recently in human evolution. Although it remains unclear whether the ancestral hominin locomotor repertoire included knuckle walking, our results suggest that it otherwise likely resembled those of African apes.

This project was funded by the Leakey Foundation and the Smithsonian Institute Fellowship Program. This work was supported by a National Science Foundation Graduate Research Fellowship (#2140001).

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## A model for the brain of the chimpanzee-human last common ancestor and early hominin frontal lobe evolution

Shawn Hurst<sup>1</sup>, Ralph Holloway<sup>2</sup>, Zach Cofran<sup>3</sup>, Heather Garvin<sup>4</sup>

1 - University of Indianapolis · 2 - Columbia University · 3 - Vassar College · 4 - Des Moines University

Studies of human brain evolution are hampered by lack of consensus on homologies between chimpanzee and human frontal lobe sulci, and lack of consensus on what the brain of the chimpanzee-human last common ancestor (CHLCA) looked like. Here we 1) provide evidence for one of two competing models of chimpanzee-human frontal sulci homologies, and evidence against the other one; 2) argue the chimpanzee brain has retained the form of the CHLCA brain; and 3) suggest the tempo and mode of frontal lobe gyri evolution.

Compared to human brains, chimpanzee brains are about 1/3rd as large, have a less globular shape, have a more posteriorly angled brainstem, have an occipital operculum marked by an anteriorly placed lunate sulcus, have a more anteriorly positioned inferior frontal sulcus, lack frontal and orbital opercula, have a non-operculated anterior insula bordered by a fronto-orbital sulcus, and have less well-defined primary frontal sulci [1]. All these traits are shared with the other great apes, despite different overall body shapes and sizes, suggesting they are ancestral traits highly conserved through millions of years of separate brain evolution, and that chimpanzees retained them from the CHLCA, which retained them from its common ancestor with gorillas and orangutans.

Where chimpanzee brain form differs most from other apes is in the superior, middle, and inferior frontal sulci, and there is no current consensus on frontal lobe sulcal homologies between chimpanzee and human brains, with two competing models being used [1-4]. Twin studies show primary brain sulci like the superior and inferior frontal are deeper, show up developmentally earlier, and are more heritable than superficial secondary and tertiary sulci like the middle frontal [5], suggesting that sulcal depth can be used to determine homologies between them. Using cortical surface reconstructions from brain MRIs we studied deep primary frontal sulci in 190 chimpanzee and 50 human brains to qualitatively determine their sulcal homologies.

These were then compared to 3D surface models and/or published descriptions of several small-brained hominin endocasts including DH3, Taung, MH1, StS 60, and Dik-1-1, and we reinterpret some hominin fossil endocasts considering our new identifications of sulcal homologies. This suggests that chimpanzees and early australopiths retain similar frontal sulci form inherited from the CHLCA, and that frontal lobe evolution proceeded in later australopiths through a lengthening of the superior and middle frontal gyri towards the frontal pole, while the inferior frontal gyrus later lengthened in early *Homo* by curving backward upon itself to create the frontal and orbital opercula covering over the anterior insula, giving Broca's language area its current form.

References: [1] Connolly, C.J., 1950. External Morphology of the Primate Brain. C. C Thomas. [2] Mingazzini, G., 1928. Beitrag zur Morphologie der äusseren Grosshirnhemisphärenoberfläche bei den Anthropoiden (Schimpanse und Orang). Archiv für Psychiatrie und Nervenkrankheiten. 85, 1-219. [3] Walker, A.E., Fulton, J.F., 1936. The external configuration of the cerebral hemispheres of the chimpanzee. Journal of Anatomy. 71, 105-129. [4] Falk, D., Zollikofer, C.P., Ponce de León, M., Semendeferi, K., Alatorre Warren, J.L., Hopkins, W.D., 2018. Identification of in vivo sulci on the external surface of eight adult chimpanzee brains: Implications for interpreting early hominin endocasts. Brain, behavior and evolution. 91, 45-58. [5] Lohmann, G., Von Cramon, D.Y., Steinmetz, H., 1999. Sulcal variability of twins. Cerebral Cortex. 9, 754-763.

Poster Presentation Number 74, Session 1, Thursday 14:00 - 15:30

## *Homo erectus* dispersal across Sundaland

Laurent Husson<sup>1</sup>, Tristan Salles<sup>2</sup>, Swann Z  r  the<sup>1</sup>, Anne- Elizabeth Lebatard<sup>3</sup>, Regis Braucher<sup>3</sup>, Sofwan Noerwidi<sup>4</sup>, Sonny Aribowo<sup>5</sup>, Claire Mallard<sup>2</sup>, Julien Carcaillet<sup>1</sup>, Danny H. Natawidjaja<sup>5</sup>, Aster Team<sup>3</sup>

1 - ISTerre, CNRS, IRD, Univ. Grenoble Alpes, Grenoble, France · 2 - School of Geosciences, The University of Sydney, Sydney, Australia · 3 - CEREGE, Aix-Marseille Universit   CNRS-IRD-Coll  ge de France-INRAE, Technop  le de l'Environnement Arbois-M  diterran  e, Aix-en-Provence, France · 4 - Research Center for Archaeometry, National Research and Innovation Agency (BRIN), Jakarta, Indonesia · 5 - Research Center for Geological Disasters, National Research and Innovation Agency (BRIN), Bandung, Indonesia

Our understanding of the evolution of the genus *Homo* during the Early Pleistocene is hampered by the piecemeal fossil archive that precludes inducing their behavior. A canonical example is the Early Pleistocene dispersal of *Homo erectus* from Africa to Southeast Asia, and the subsequent peopling of Java Island in particular, where the relative abundant fossil discoveries stand in contrast to the near-absence of comparable finds elsewhere in the region. This discrepancy is even more striking given Java's insular physiographic context.

Refining the chronology of dispersal of *Homo erectus* from mainland Asia to Java Island, and across Sundaland, is of course a crucial task that may increase the numbers of milestones and that shall be pursued, but keeping in mind that it might not suffice in the short term to close the spatial-temporal gaps. In that purpose, we revisit the earliest appearance of *Homo erectus* in Sangiran, Java by adding constraints based on cosmogenic nuclides – which turns out to be the most parsimonious method – to a compilation of earlier estimates. We find that an early arrival in Java, ca. 1.8 Ma [1], is most probable.

This revised timeline raises the question about the dynamics and pathways of *H. erectus* dispersal from Africa and mainland Asia to Java across the complex environments of the Sunda shelf. To address this, we adopt a deductive framework, employing a suite of predictive models that allow reconstructing the transient physical environment during Late Pleistocene, and their subsequent dispersal across Sundaland. It follows that the quickly changing landscape in this region profoundly determined the modes of dispersal of *Homo erectus*. Geodynamic models indicate that the lithosphere and mantle dynamics permanently sustained a largely emergent continental Sundaland for most of the Pleistocene, while the Indonesian arc –including Java Island– coevally emerged from the sea. Landscape elevation models forced by these geodynamic reconstructions and by complementary climate models indicate that the Early Pleistocene physiography of Sundaland was critically different from the present-day one, with a limited number of watersheds tessellating the continental Sunda shelf.

In an attempt to assess the dispersal of hominins across the shelf, accounting for the quickly changing environments shall thus not be bypassed. We therefore take advantage of the reconstructed landscapes at the time of dispersal to deploy ecological models constrained by terrain parameters such as elevations and hydrological factors, known to influence behavior of movement and settlement. Acknowledging the inherent stochasticity of dispersal processes, we opted for a probabilistic approach. We find that the dispersal across Sundaland likely occurred over tens to hundred kyrs, and that *Homo erectus* reached across the subsiding Sundaland, while Java Island conversely emerged from the sea.

Finally, our reconstructed dispersal pathways indicate that likely locations for early occupation are now either deeply buried beneath sediments, like the Chao Praya plain, or submerged beneath modern coastal water, like the Mekong delta. We provide an answer to Eugene Dubois's concern more than a century ago, and argue that if Java displays an apparently abundant collection of fossil remnants, it is mostly due to the conditions of exposure offered by an otherwise not so probable site of residence.

Authors are grateful to Nandang from LIPI Geotek for his continued involvement in the field, to the people of Sangiran for their assistance, and to the Museum Situs Manusia Purba Sangiran and Tanto for their guidance. The authors thank J. Arief for his help in the field, F. Semah and C. Falgu  res for discussions, L. L  anni for her valuable assistance during chemical treatments and ICP-OES measurements, and D. Daddi-Addoun for her support. Our colleague and friend Didier L. Bourl  s, who passed away in 2021, instigated this study.

References: [1] Husson, L., Salles, T., Lebatard, A-E., Z  r  the, S., Braucher, R., Noerwidi, S., Aribowo, S., Mallard, C., Carcaillet, J., Natwidjaja, D.H., Bourl  s, D., ASTER team, 2022, Javanese *Homo erectus* on the move in SE Asia circa 1.8 Ma. *Scientific Reports*. 12, 19012.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Evaluating heel-strike and toe-off mechanics in *Australopithecus afarensis* using finite element modeling

Alexandra C. Idso<sup>1,2</sup>, Ailis M. Daly<sup>2,3</sup>, Herman Pontzer<sup>2,4,5</sup>, Nicole M. Webb<sup>6,7</sup>, William E.H. Harcourt Smith<sup>1,2,8,9,10</sup>

1 - Department of Anthropology, The Graduate Center, City University of New York · 2 - New York Consortium in Evolutionary Primatology · 3 - Center for the Study of Human Origins, Department of Anthropology, New York University · 4 - Department of Evolutionary Anthropology, Duke University · 5 · Duke Global Health Institute, Duke University · 6 - Senckenberg Research Institute and Natural History Museum Frankfurt, Frankfurt, Germany · 7 - Institute of Evolutionary Medicine, University of Zurich, Zurich, Switzerland · 8 - Department of Anthropology, Lehman College, City University of New York · 9 - Division of Paleontology, American Museum of Natural History · 10 - Evolutionary Studies Institute, University of the Witwatersrand South Africa

The locomotor affinities and gait kinematics of *Australopithecus afarensis* have sparked more debate than any other fossil hominin due to the extensive postcranial material available for the taxon [1-5]. These specimens exhibit an intriguing combination of primitive and derived morphologies that some researchers have cited as indicating a flexed limb gait with some pedal grasping within a mixed arboreal and terrestrial context. In contrast, others have argued for strictly human-like gait mechanics. The vertical orientation and metaphyseal flaring adjacent to the joint surfaces of the tibia, unwedged talus, and expanded calcaneal tuber with a moderately developed lateral plantar process have been used to support a human-like heel-strike with extended limbs. Elsewhere, the proximal articular dorsal morphology and dorsal doming of the head of the first metatarsal (MT1) have been used to argue for a human-like toe-off.

However, the relationship between *A. afarensis* lower limb morphology and its role in dissipating the high forces generated during bipedal gait has yet to be tested. Thus, it remains unclear whether *A. afarensis* walked bipedally with lower limb mechanics similar to *Homo sapiens*. Accordingly, we conducted a series of finite element simulations of the *A. afarensis* lower limb during bipedal walking. We also compared their performance to models of *H. sapiens* and *Pan troglodytes* under the same loading scenarios. A sample of FE models generated from surface scans of *H. sapiens* (n=5), *P. troglodytes* (n=5), and *A. afarensis* (A.L. 288-1, A.L. 333-54, -8, and -115a) tibia, tali, calcanei, and MT1s were generated under body mass normalized loading conditions to simulate modern human-like bipedal gait based on previously collected kinematic data and published material property values. The tibiae, tali, and calcanei were modeled at simulated heel-strike and the MT1s at simulated toe-off to test hypotheses relating to the morphological adaptation of these elements to the peak forces generated at these key moments of gait.

In all elements, the visual representation of the von Mises stress plots and descriptive statistics of bipedal simulations shows that *H. sapiens* exhibits considerably lower median scaled stress values than *P. troglodytes*. These findings offer experimental support for long-assumed form-function relationships. In the tibia and talus human-like heel-strike models, *A. afarensis* displays a magnitude of stress most similar to *H. sapiens*. However, the *A. afarensis* models display stress accumulation in the distal tibia and talar neck, distinct from patterns in the *H. sapiens* models. In the calcaneal and MT1 models, *A. afarensis* shows stress magnitudes intermediate to those of *H. sapiens* and *P. troglodytes*. These combined findings suggest that *A. afarensis* was likely adapted for a unique bipedal gait that may have involved subtle yet interesting differences in critical phases of the gait cycle, such as heel-strike and toe-off. However, further tests using alternative gait mechanics and additional elements are planned to fully understand the functional adaptations in the lower limb of *A. afarensis*.

References: [1] Fernández, P.J., Mongle, C.S., Leakey, L., Proctor, D.J., Orr, C.M., Patel, B.A., Almécija, S., Tocheri, M.W., Jungers, W.L., 2018. Evolution and function of the hominin forefoot. *Proceedings of the National Academy of Sciences*. 115, 8746–8751. [2] Latimer, B., Lovejoy, C.O., 1989. The calcaneus of *Australopithecus afarensis* and its implications for the evolution of bipedality. *American Journal of Physical Anthropology*. 78, 369–386. [3] Latimer, B., Lovejoy, C.O., 1990. Hallucal tarsometatarsal joint in *Australopithecus afarensis*. *American Journal of Physical Anthropology*. 82, 125–133. [4] Stern Jr., J.T., Susman, R.L., 1983. The locomotor anatomy of *Australopithecus afarensis*. *American Journal of Physical Anthropology*. 60, 279–317. [5] Ward, C.V., 2013. Postural and locomotor adaptations of *Australopithecus* species. *The Paleobiology of Australopithecus*. 235–245.

Poster Presentation Number 75, Session 1, Thursday 14:00 - 15:30

## Rethinking dental traits in hominin origins: insights from *Ouranopithecus macedoniensis* (Late Miocene, Greece)

Melania Ioannidou<sup>1</sup>, George D. Koufos<sup>2</sup>, Katerina Harvati<sup>1,3</sup>

1 - Paleoanthropology, Institute for Archaeological Sciences and Senckenberg Centre for Human Evolution and Palaeoenvironment, Department of Geosciences, Eberhard-Karls University of Tübingen, Germany · 2 - School of Geology, Laboratory of Geology and Paleontology, Aristotle University of Thessaloniki, Greece · 3 - DFG Center for Advanced Studies 'Words, Bones, Genes, Tools', Eberhard-Karls University of Tübingen, Germany

Traits such as reduced root and pulp canal number have been proposed as indicators of hominin status in some Late Miocene fossils, including *Graecopithecus freybergi* from Southeastern Europe [1]. In this study, we examine the internal post-canine mandibular dental morphology of *Ouranopithecus macedoniensis* using high-resolution 3D imaging to assess whether similar patterns occur in this much-discussed taxon, which has also been proposed as a potential hominin (e.g., [2,3]).

*Ouranopithecus macedoniensis* is an important Late Miocene hominoid from the deposits of Northern Greece (~9.6–8.9 Ma). Since its discovery in 1974, this species has been at the center of debates regarding the taxonomy and evolution of Late Miocene apes. Despite a well-represented fossil record, its internal dental anatomy, particularly root and pulp canal morphology, remains underexplored. To address this, we analyzed mandibular specimens from the Ravin de la Pluie (RPI) and Nikiti (NKT) localities using high-resolution 3D imaging techniques.

Our results reveal generally consistent root structures, with most variation observed in the premolars, including cases of root and pulp reduction. This study documents previously unreported internal dental variation in *O. macedoniensis*, contributing valuable comparative data on Miocene hominoid dental diversity. However, our findings also suggest that such traits may reflect broader variability among Miocene hominoids rather than serving as reliable diagnostic markers for early hominin status. These findings impact interpretations of *Graecopithecus freybergi*, where similar traits have been used to support hominin affinities, suggesting instead that such features may fall within the broader spectrum of Miocene hominoid variation.

Overall, the findings in this study raise caution in using such characters as hominin-specific traits and highlight the need for broader comparative frameworks that incorporate internal morphology in Miocene apes. By refining methods and expectations around dental variation, this study contributes to the ongoing reassessment of phylogenetic signals in early hominin evolution.

This work was supported by the Senckenberg Gesellschaft für Naturforschung, the Deutsche Forschungsgemeinschaft (DFG INST 37/706-1) and the 2021 DFG Leibniz award, awarded to Katerina Harvati.

References: [1] Fuss, J., Spassov, N., Begun, D.R., Böhme, M., 2017. Potential hominin affinities of *Graecopithecus* from the Late Miocene of Europe. *PLoS one*. 12, e0177127. [2] de Bonis, L., Bouvrain, G., Geraads, D., Koufos, G., 1990. New hominid skull material from the late Miocene of Macedonia in Northern Greece. *Nature*. 345, 712. [3] Koufos, G.D., de Bonis, L., 2005. The Late Miocene hominoids *Ouranopithecus* and *Graecopithecus*. Implications about their relationships and taxonomy. *Annales de Paléontologie*. 91, 227-240.

Poster Presentation Number 76, Session 1, Thursday 14:00 - 15:30

## The dental morphology of Aurignacian makers: new phenotypic data from the human remains of Les Rois (France)

Jerome Isle de Beauchaine<sup>1</sup>, Gaël Becam<sup>2</sup>, Florent Déroit<sup>1</sup>, Dominique Grimaud-Hervé<sup>1</sup>, Christine Verna<sup>1</sup>

1. UMR 7194 HNHP, MNHN-CNRS-UPVD, Musée de l'Homme, Paris, France · 2. UMR 7194 HNHP, MNHN-CNRS-UPVD, Tautavel, France

The phenotypic characteristics of human populations associated with an Aurignacian (*s.l.*) context in Europe remain largely unknown. This lack of knowledge is mainly due to the reduced number of human remains discovered from this period (~42-32 ka BP), scattered across the European continent [1]. This scarcity of Aurignacian remains led to major debates in the past about their taxonomic identity [2], in the context of population replacement leading to the disappearance of the Neanderthals and the establishment in Europe of *Homo sapiens* populations. Although there now seems to be a consensus on the attribution of Early and Late Aurignacian technocomplexes to *Homo sapiens*, the morphological characteristics of certain specimens place them outside the variability of recent *Homo sapiens*, and bring them closer to Neanderthals [3]. As the phenotypic variability of these Early Upper Paleolithic groups is still unknown, their morphological features can be challenging to interpret. To contribute to these discussions, we present a new comprehensive study of the phenotypic characteristics of dental remains discovered at Les Rois cave, in south-west France. Using new micro-tomographic data of a large comparative sample of *Homo neanderthalensis*, Pleistocene, and Holocene *Homo sapiens*, we analyzed dental metrics, 3D dental tissue proportions [4], Enamel Dentine Junction (EDJ) non-metric trait variations [5], and 3D Geometric-morphometrics. Our study confirms the taxonomical attribution of the Les Rois remains to *Homo sapiens*, with the presence of anatomical features that are indeed rare among recent *Homo sapiens* populations but also different from the Neanderthal dental morphology. With these new results, our study aims to contribute to a better understanding of the morphology of Aurignacian makers and to discuss the interpretation of the morphological characteristics of these populations, paving the way for new discussions on the population dynamics during the Early Upper Paleolithic in Europe.

Funding: UMR 7194 HNHP, MNHN. Access to the Les Rois collection: Anna Echassoux, IPH, Paris. CT-scan acquisition: Marta Bellato, UAR 2700 - 2AD MNHN. RET analysis protocol: Adrien Thibault, UMR 5199 CNRS, Bordeaux, GMM 3D protocol: Florent Déroit, UMR 7194 CNRS, Musée de l'Homme. CT-scan data segmentation assistance: Jonathan Özçelebi, UMR 7194 CNRS. Comparative data: Gaël Becam, UMR 7194 CNRS, Perpignan, France; Matthew M. Skinner, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany. ESRF Paleontological Database online & NESPOS society

References: [1] Hublin, J.-J., 2015. The modern human colonization of western Eurasia: when and where? *Quaternary Science Reviews*. 118, 194–210. [2] Bailey, S.E., Weaver, T.D., Hublin, J.-J., 2009. Who made the Aurignacian and other early Upper Paleolithic industries? *Journal of Human Evolution*. 57, 11–26. [3] Rozzi, F. R., d'Errico, F., Vanhaeren, M., Grootes, P. M., Kerautret, B., & Dujardin, V., 2009. Cutmarked human remains bearing Neandertal features and modern human remains associated with the Aurignacian at Les Rois. *Journal of Anthropological Sciences*, 87, 153-185. [4] Benazzi, S., Panetta, D., Fornai, C., Toussaint, M., Gruppioni, G., Hublin, J., 2013. Technical Note: Guidelines for the digital computation of 2D and 3D enamel thickness in hominoid teeth. *American Journal of Physical Anthropology*. 153, 305–313. [5] Krenn, V.A., Fornai, C., Wurm, L., Bookstein, F.L., Haeusler, M., Weber, G.W., 2019. Variation of 3D outer and inner crown morphology in modern human mandibular premolars. *American Journal of Physical Anthropology*. 169, 646–663.

Poster Presentation Number 77, Session 1, Thursday 14:00 - 15:30

## Exploring a cultural-industrial entity through lithic comparison: the lithic assemblage of Aghitu-3 Cave

Firas Jabbour<sup>1</sup>, Boris Gasparian<sup>2</sup>, Andrew W. Kandel<sup>3</sup>

1 - Eberhard Karls University of Tübingen, Department of Early Prehistory and Quaternary Ecology · 2 - Institute of Archaeology and Ethnography, National Academy of Sciences, Yerevan State University · 3 - The Role of Culture in Early Expansions of Humans (ROCEEH), Heidelberg Academy of Sciences and Humanities at the University of Tübingen

This paper presents a study of lithic artifacts from Aghitu-3 Cave in Armenia, aiming to contextualize the site within the broader lithic technological framework of the Armenian Highlands and Caucasus and explore its relation to surrounding sites. More broadly, it seeks to understand the Armenian Highlands as a distinctive cultural entity during the Upper Paleolithic.

Aghitu-3, located in southern Armenia, lies in the Vorotan River gorge. Excavations revealed five archaeological horizons spanning the Early and Middle Upper Paleolithic. The site yielded significant finds, including shell beads, an eyed bone needle, other bone tools, a large lithic assemblage, and faunal remains. Based on the techno-typological study of the lithics and the stratigraphy, four main occupation phases are identified:

Phase 1 (AH VII, 40,000–36,000 cal BP) includes large, narrow-faced burin-like, unidirectional or bidirectional cores, with plain or faceted platforms, often reduced using hard hammerstones.

Phase 2 (AH VI.1a, VI.1, VI.0; 36,000–32,000 cal BP) features small, wide-faced, cortical, unidirectional bladelet cores (though rare). Retouched bladelets dominate; domestic tools are scarce.

Phase 3 (AH IIIId–b; 29,000–26,000 cal BP) is the richest in artifacts. Cores are mostly wide-faced, cortical, unidirectional bladelet types, along with narrow-faced and cores on flakes. Retouched bladelets, with the presence of backed bladelets dominate. Various retouched bladelet types were found, including points and lateral retouched bladelets on both sides. Domestic tools such as burins, end scrapers, denticulates, and drills were also present.

Phase 4 (AH IIIa; 26,000–24,000 cal BP): While previous reduction technology persisted, tool types changed notably with the disappearance of points and the appearance of both truncated bladelets and some microlithics, alongside extremely backed bladelets. However, the technological features and dating of this layer prevent its attribution to the Late Upper Paleolithic; rather, it provides evidence of a transition towards it.

The large cores and distinct technology in Phase 1 suggest technological divergence from later phases and may align with the Initial Upper Paleolithic. Although Phases 2 and 3 share some key features with the Baradostian (Zagros) and Early and Late Ahmarian (Levant) industries, the absence of diagnostic tools like Arjeneh and El-Wad points [1], [2], and geographic distance, limit direct comparison.

However, closer regional sites provide more reliable insights. Phase 2 aligns with Dzudzuana Layer D, Ortvale Klde Layer 4, and Mezmaiskaya Layer C [3], [4], [5], all characterized by wide-faced, unidirectional cores and prevalent retouched bladelets with few backed tools.

Phase 3 resembles Dzudzuana Layer C, Bondi Layer 4, Samertskhle Klde, and Mezmaiskaya Layers 1A–2 [3], [4], [5], with similar unidirectional bladelet core use and tool types based on laminar blanks, such as laterally retouched and backed bladelets.

Phase 4 parallels Satsurbliia Cave Layer B/II in core technology, retouched bladelet types, and increased backed bladelets, along with the appearance of truncated points and geometric tools.

Thus, the technological consistency across the various layers of Aghitu-3 with sites in the southern Caucasus suggests the existence of a shared cultural-industrial entity, which maintained regional connections but preserved its own distinctive features. This warrants further study to define its characteristics as a technological and cultural system linked to its geographic setting and technological-cultural attributes.

Acknowledgements to Gerda Henkel Stiftung

References: [1] Shea, J.J., 2012. Lithic Modes A–I: A New Framework for Describing Global-Scale Variation in Stone Tool Technology Illustrated with Evidence from the East Mediterranean Levant. *Journal of Archaeological Method and Theory*. 20, 151–186. [2] Otte, M., Bazgir, B., Tumung, L., Ollé, A., Deo, S. G., Joglekar, P., López-García, J. M., Picin, A., Davoudi, D., & van der Made, J. (2014). Test excavations and initial results at the Middle and Upper Paleolithic sites of Gilvaran, Kaldar, Ghamari Caves and Gar Arjene Rockshelter, Khorramabad Valley, western Iran. *Comptes Rendus Palevol*, 13(6), 511–525. <https://doi.org/10.1016/j.crpv.2014.01.005> [3] Adler, D.S., Bar-Yosef, O., Belfer-Cohen, A., Tushabramishvili, N., Boaretto, E., Mercier, N., Valladas, H., Rink, W.J., 2008. Dating the demise: Neandertal extinction and the establishment of modern humans in the southern Caucasus. *Journal of Human Evolution*. 55, 817–833. [4] Bar-Yosef, O., Belfer-Cohen, A., Mesheviliani, T., Jakeli, N., Bar-Oz, G., Boaretto, E., Goldberg, P., Kvavadze, E., Matskevich, Z., 2011. Dzudzuana: an Upper Palaeolithic cave site in the Caucasus foothills (Georgia). *Antiquity*. 85, 331–349. [5] Golovanova, L. V., & Doronichev, V. B. (2020). *Environment, culture and subsistence of humans in the Caucasus between 40,000 and 10,000 years ago*. Cambridge Scholars Publishing

Poster Presentation Number 78, Session 1, Thursday 14:00 - 15:30

## Rethinking *Paranthropus*: new insights from an enigmatic juvenile from Swartkrans, South Africa

Renaud Joannes-Boyau<sup>1</sup>, Clément Zanolli<sup>2,6</sup>, Manish Arora<sup>3</sup>, Christine Austin<sup>3</sup>, Ian Moffat<sup>4</sup>, Luca Fiorenza<sup>5</sup>, Justin W. Adams<sup>5</sup>, Gideon Chinamatira<sup>6</sup>, Lazarus Kgasi<sup>8</sup>, Mirriam Tawane<sup>7</sup>, Song Xing<sup>9,10</sup>

1 - Geoarchaeology and Archaeometry Research Group (GARG), Southern Cross University, Lismore, NSW, Australia · 2 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France · 3 - Department of Environmental Medicine and Climate Science, Icahn School of Medicine at Mount Sinai, New York, USA · 4 - Archaeology, College of Humanities, Arts and Social Sciences, Flinders University, Australia · 5 - Biomedicine Discovery Institute, Monash University, Melbourne, Victoria, Australia · 6 - Evolutionary Studies Institute, University of the Witwatersrand, 1 Jan Smuts Avenue, Braamfontein, Johannesburg, South Africa · 7 - Palaeo-Research Institute, University of Johannesburg, Gauteng Province, South Africa · 8 - National Heritage Council, Pretoria, South Africa · 9 - Institute of Vertebrate Paleontology and Paleoanthropology, Research institute in Beijing, China · 10 - CAS Center for Excellence in Life and Palaeoenvironment, Beijing, China

SK 96 is a fragment of juvenile mandible bearing the dm1 roots, as well as the developing C1 and P3 found in Member 1 Hanging Remnant (2.2–1.8 Ma) at Swartkrans, in South Africa [1]. Since its discovery, this specimen has long puzzled researchers due to the unusual morphology of the permanent teeth compared to other *Paranthropus* specimens from Swartkrans. Analyses of the P3 enamel-dentine junction (EDJ) suggested that SK 96 is compatible with *Paranthropus* [2,3], but also showed similarities with *Homo naledi* [3]. Traditionally classified as *Paranthropus robustus*, this specimen shows subtle but consistent differences with the teeth of the latter species and the recent recognition of the species *Paranthropus capensis* [4] prompted a fresh look at its identity.

Using advanced 3D imaging approaches and geochemical analyses, we re-evaluate SK 96's dental structure, early-life development, and landscape use. Diffeomorphic-based geometric morphometric analyses of the EDJ were conducted on both C1 and P3. Dental development stages of the permanent teeth were scored. Geochemical mapping of Li, Ba and Sr allowed us to characterise the early life exposome of this juvenile individual. Strontium isotopes were measured to reconstruct the mobility and behaviour of SK 96.

The shape of the EDJ of both C1 and P3 supports an attribution of SK 96 to *Paranthropus*, even if it also differs in some aspects from most of the *P. robustus* specimens from Swartkrans and Drimolen included in our analyses. Geochemical analyses revealed five phases of Ba, Sr and Li accumulation in the dental tissues corresponding to different feeding stages, from a short exclusive breastfeeding period to weaning, with some intermediate phases of seasonal dietary stress and/or prolonged weaning strategy. Strontium isotope analyses demonstrate that this SK 96 was non-local to Swartkrans.

Our findings thus point to a possible reassignment of SK 96 to *Paranthropus capensis*, corroborating the hypothesis of a larger taxonomic and ecological diversity in southern African hominins than previously recognised [4]. The relatively short exclusive nursing period and early transition to solid food in SK 96 suggests a different adaptation strategy than in *Australopithecus africanus* [5], possibly linked to ecological pressures such as local resource availability or social behaviour related to group provisioning strategies. The non-local strontium isotope values of SK 96 also suggest that this individual and its family either migrated into the Swartkrans area or was part of a group with a more varied home range than generally reported for *Paranthropus robustus*. This is another indicator of increased diversity within *Paranthropus* in southern Africa, which could support different ecological niches between *P. robustus* and *P. capensis*. This study highlights how even fragmentary fossils can reshape our understanding of human evolution and underscores the power of integrating morphology, chemistry, and developmental data to uncover the life history of our ancient relatives.

University of the Witwatersrand, Ditsong National Museum of Natural History, National Museum of Kenya, Senckenberg Museum, Max Planck Institute for Evolutionary Anthropology. Research funded by: University of Bordeaux's IdEx "Investments for the Future" program/GPR "Human Past"; Erasmus+ Programme of the European Union Bakeng se Afrika, CNRS, Max Planck Society.

References: [1] Robinson, J.T., 1956. The Dentition of the *Australopithecinae*. Transvaal Museum, Pretoria. [2] Zanolli, C., Davies, T.W., Joannes-Boyau, R., Beaudet, A., Bruxelles, L., de Beer, F., Hoffman, J., Hublin, J.-J., Jakata, K., Kgasi, L., Kullmer, O., Macchiarelli, R., Pan, L., Schrenk, F., Santos, F., Stratford, D., Tawane, M., Thackeray, F., Xing, S., Zipfel, B., Skinner, M.M., 2022. Dental data challenge the ubiquitous presence of *Homo* in the Cradle of Humankind. Proceedings of the National Academy of Sciences. USA 119, e2111212119. [3] Davies, T.W., Deleuzene, L.K., Gunz, P., Hublin, J.-J., Berger, L.R., Gidna, A., Skinner, M.M., 2020. Distinct mandibular premolar crown morphology in *Homo naledi* and its implications for the evolution of *Homo* species in southern Africa. Scientific Reports. 10, 13196. [4] Zanolli, C., Hublin, J.-J., Kullmer, O., Schrenk, F., Kgasi, L., Tawane, M., Xing, S., 2025. Taxonomic revision of the SK 15 mandible based on bone and tooth structural organization. Journal of Humankind. 200, 103634. [5] Joannes-Boyau, R., Adams, J.W., Austin, C., Arora, M., Moffat, I., Herries, A.I.R., Tonge, M.P., Benazzi, S., Evans, A.R., Kullmer, O., Wroe, S., Dosseto, A., Fiorenza, L., 2019. Elemental signatures of *Australopithecus africanus* teeth reveal seasonal dietary stress. Nature. 572, 112–115.

Poster Presentation Number 79, Session 1, Thursday 14:00 - 15:30

## **Building theoretically informed contextualised understandings of deep time symbolic behaviours in Sunda and Sahul**

Tristen Jones<sup>1</sup>, Sue O'Connor<sup>2</sup>

1 - The University of Sydney · 2 - The Australian National University

Recent innovations in the sampling methods that target datable materials using radiocarbon associated with rock art [1] has greatly enhanced the capacity of rock art researchers to date rock art, producing a range of age determinations for a diversity of rock art styles in Australia [2, 3]. Age determinations generated by uranium series dating from a range of rock art motifs from across Island South East Asia [4] has drastically revised our understanding of the evolution of ancient symbolic behaviours globally. Despite the ground-breaking nature of these results, the impact and benefit of these age determinations in enhancing our understanding of the sociocultural function of symbolic behaviours and their use by human groups in deep time remains limited due to the lack of contextualised rock art research that seeks to understand the chronological and stylistic relationships between the dated motifs, the broader motif assemblage and their archaeological and environmental contexts hampering the ability to undertake robust interregional analysis [5]. In this paper we identify current gaps in knowledges; suggest research pathways forward to build more theoretically and contextually informed interpretations; and explore the ramifications of these findings for the evolution of symbolic behaviour in our region.

References: References: [1] Green, et al. 2021 "Micro-stromatolitic laminations and the origins of engraved, oxalate-rich accretions from Australian rock art shelters." *Genarchaeology*. [2] Finch et al. 2021 "Ages for Australia's oldest rock paintings." *Nature human behaviour*. [3] Jones et al. 2017 "Radiocarbon age constraints for a Pleistocene–Holocene transition rock art style: the Northern Running Figures of the East Alligator River region, western Arnhem Land, Australia." *Journal of Archaeological Science: Reports*; [4] Oktaviana et al. 2024 "Narrative cave art in Indonesia by 51,200 years ago." *Nature*; [5] Brumm et al. 2024 "Some implications of Pleistocene Figurative Rock Art in Indonesia and Australia." *Deep-Time Images in the Age of Globalization: Rock Art in the 21st Century*.

Poster Presentation Number 80, Session 1, Thursday 14:00 - 15:30

## Genetic capacities and cultural realization: reinterpreting paleogenetic findings on *Homo sapiens* and Neandertals

Armin Kaiser<sup>1</sup>, Frederick L. Coolidge<sup>2</sup>

1 - University of Tuebingen · 2 - University of Colorado, Colorado Springs

Recent paleogenetic studies have identified several gene variants, such as ARHGAP11B [1], MCPH1 [2], and TKTL1 [3], that differ between modern *Homo sapiens* and Neandertals and are implicated in neocortical development, particularly in the frontal lobes. Functional studies using cerebral organoids suggest that some of these variants may enhance neural proliferation, alter mitotic timing, or increase the number of upper-layer neurons in the developing neocortex. These findings open up promising avenues for exploring the biological substrates of cognition in the hominin lineage. However, the cognitive relevance of such genetic changes must be interpreted with care. While some authors (e.g., Coolidge & Wynn [4]) have emphasized the role of working memory and executive function in the emergence of modern cognition, and others have linked specific genetic variants to neurodevelopmental advantages, we argue that these genes provide developmental potential, not deterministic outcomes. The actualization of such capacities likely depended on demographic factors (e.g., group size, generational continuity) and cultural scaffolding, including sustained training, symbolic communication, and social learning. This perspective is compatible with Cecilia Heyes' [5] theory of *cognitive gadgets*, where high-level cognitive functions are culturally constructed rather than genetically preprogrammed. Michael Walker's view of working memory as a platform for cultural memory and symbolic sequencing further underscores the importance of lifelong plasticity and social embedding. From this viewpoint, the frontal cortex—rather than being a fixed “control center”—can be metaphorically reframed as a resonant space, tuned and shaped by cumulative cultural input. In summary, we propose a model of cognitive evolution in which genetic infrastructure and cultural realization are mutually entangled. This allows us to integrate paleogenetic findings without reducing behavioral differences between *Homo sapiens* and Neandertals to simple genetic causality.

We'd like to thank Dr. Michael J. Walker for his insights and inspiration.

References: [1] Namba, T., Huttner, W.B., 2024. What makes us human: insights from the evolution and development of the human neocortex. *Annual Review of Cell and Developmental Biology*. 40, 427-452. [2] Evans, P.D., Gilbert, S.L., Mekel-Bobrov, N., Vallender, E.J., Anderson, J.R., Vaez-Azizi, L.M., Tishkoff, S.A., Hudson, R.R., Lahn, B.T., 2005. Microcephalin, a gene regulating brain size, continues to evolve adaptively in humans. *Science*. 309, 1717-1720. [3] Pinson, A., Xing, L., Namba, T., Kalebic, N., Peters, J., Oegema, C.E., Traikov, S., Reppe, K., Riesenberger, S., Maricic, T., Derihaci, R., Wimberger, P., Pääbo, S., Huttner, W.B., 2022. Human TKTL1 implies greater neurogenesis in frontal neocortex of modern humans than Neanderthals. *Science*. 377, eabl6422. [4] Coolidge, F.L., Wynn, T., 2005. Working memory, its executive functions, and the emergence of modern thinking. *Cambridge Archaeological Journal*. 15, 5-26. [5] Heyes, C., 2018. *Cognitive Gadgets: The Cultural Evolution of Thinking*. Harvard University Press. Harvard, MA, USA.

Poster Presentation Number 81, Session 1, Thursday 14:00 - 15:30

## ***roadDB* – A new R package to facilitate data retrieval from the ROCEEH Out of Africa Database (ROAD)**

Andrew W. Kandel<sup>1</sup>, Christian Sommer<sup>1,2</sup>, Volker Hochschild<sup>1,2</sup>, Jesper Borre Pedersen<sup>1</sup>, Timo Streicher<sup>1</sup>, Zara Kanaeva<sup>1</sup>

1 - The Role of Culture in Early Expansions of Humans (ROCEEH), Heidelberg Academy of Sciences and Humanities at the University of Tübingen, Tübingen, Germany · 2 - Department of Geosciences, Institute of Geography, University of Tübingen, Tübingen, Germany

The ROCEEH Out of Africa Database (ROAD) continues to grow and now includes the largest collection of archaeological sites spanning Africa and Eurasia from 3 Ma to 20 ka [1]. When the ROCEEH research center started in 2008 (<https://www.hadw-bw.de/en/research/research-center/roceeh/home>), one goal was to design an open-access, online database to help researchers answer large-scale questions related to the expansions of early humans across the globe. ROCEEH spent the next 17 years aggregating data about human evolution from the disciplines of archaeology, paleoanthropology, paleontology, paleobotany and paleogeography. ROAD is a relational database implemented with a PostgreSQL database management system. Additionally, ROAD links spatial information within a geodata infrastructure to publish and distribute spatial data through web services and interactive applications.

This poster presents the new R package *roadDB* [2] developed by our team to facilitate data retrieval. This tool helps R users access data directly from ROAD, within the R statistical environment, and enables them to manipulate it for analysis using the statistical and graphical packages R offers [3]. The implementation of *roadDB* opens the entire database to users' queries and exemplifies our philosophy to make it FAIR (Findable, Accessible, Interoperable, Reusable) [4].

Until now, research partners could retrieve tabular data from ROADweb in several ways. Using the application Ask ROAD introduced in 2024 [5], users can extract data without prior knowledge of the database structure or programming language. In the ROADweb interface, users can perform simple filters on a single table to get basic results or employ the SQL query tool to join several tables and runs queries. Users can compose more advanced queries with flexible grouping using the SPARQL endpoint or by collaborating directly with our team. By viewing the results in ROADweb or accessing them through the provided URL, users can download the data in interoperable formats such as csv, html, xml and json.

The R package *roadDB* allows a user to access and retrieve data from ROAD and transfer the data into their analytical pipelines in the R environment. We strove to simplify the process of querying data from ROAD by introducing R functions typical of the look and feel well known to experienced R users. To maximize interoperability and compatibility with other popular R libraries, we deliver the results as R data frames.

The R package contains a number of functions that allow users to retrieve data at three levels of granularity. The first and highest level is the locality or site with its geographic information. The second level is the assemblage containing cultural, human, animal and plant remains. The third and finest level deals with absolute dating of the assemblages and the geological layers in which they are found. All functions can be used to customize queries by constraining the search through compulsory and optional attributes and to organize the output tables. Furthermore, helper functions allow the user to understand the contents of ROAD in an intuitive way. As a result, this new tool serves as a utility for different target groups in the scientific community, for example, ecologists who desire geographical and biological information for species distribution models or archaeologists who require absolute dating information to conduct time series analysis. Thus, *roadDB* counts among the many useful R packages such as *rcarbon*, *pastclim*, *tidysdm* or *stratigraphr* that are already key components of the archaeologist's tool-kit.

Now that *roadDB* is available and as ROCEEH comes to a close in 2027, we have streamlined the processes allowing users to gather data from ROAD. We encourage you to visit ROAD (<https://www.roceeh.uni-tuebingen.de/roadweb/>) which is accessible to everyone with or without a login. Discover for yourself what ROAD can do!

References: [1] Kandel, A.W., Sommer, C., Kanaeva, Z., Bolus, M., Bruch, A.A., Groth, C., Haidle, M.N., Hertler, C., Heß, J., Malina, M., Märker, M., Hochschild, V., Mosbrugger, V., Schrenk, F., Conard, N.J., 2023. The ROCEEH Out of Africa Database (ROAD): A large-scale research database serves as an indispensable tool for human evolutionary studies. *PLOS ONE*. 18, e0289513. [2] *roadDB*, 2025. <https://github.com/sommergeo/roadDB> (available online in Sept. 2025). [3] R Core Team, 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org>. [4] Wilkinson, M.D., Dumontier, M., Aalbersberg, I.J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.-W., da Silva Santos, L.B., Bourne, P.E., Bouwman, J., Brookes, A.J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C.T., Finkers, R., Gonzalez-Beltran, A., Gray, A.J.G., Groth, P., Goble, C., Grethe, J.S., Heringa, J., 't Hoen, P.A.C., Hooft, R., Kuhn, T., Kok, R., Kok, J., Lusher, S.J., Martone, M.E., Mons, A., Packer, A.L., Persson, B., Rocca-Serra, P., Roos, M., van Schaik, R., Sansone, S.-A., Schultes, E., Sengstag, T., Slater, T., Strawn, G., Swertz, M.A., Thompson, M., van der Lei, J., van Mulligen, E., Velterop, J., Waagmeester, A., Wittenburg, P., Wolstencroft, K., Zhao, J., Mons, B., 2016. The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*. 3, 160018. [5] Kandel, A.W., Haidle, M.N., Hochschild, V., Kanaeva, Z., Conard, N.J., 2024. Ask ROAD – a New Tool for Retrieving Data from the ROCEEH Out of Africa Database (ROAD). *Paleoanthropology*. 2024, 454.

Poster Presentation Number 82, Session 1, Thursday 14:00 - 15:30

## Reconstructing Late Miocene paleoenvironments of Toros-Menalla (Chad) using 3D geometric morphometrics of bovid astragali

Julian Karoui-Canedo<sup>1</sup>, Cécile Blondel<sup>1</sup>, Nekoulngang D. Clarisse<sup>2</sup>, Djimdoumbaye Ahounta<sup>2</sup>, Andossa Likius<sup>4,5</sup>, Hassane-Taisso Mackaye<sup>4,6</sup>, Adoum Mahamat<sup>2</sup>, Abderamane Moussa<sup>4</sup>, Franck Guy<sup>1</sup>, Jean-Renaud Boisserie<sup>1,3</sup>

1 - Laboratoire de Paléontologie, Evolution, Paléoécosystèmes et Paléoprimatologie (PALEVOPRIM), Université de Poitiers, CNRS, Poitiers, France · 2 - Service de Conservation et Valorisation des Collections Paléontologiques, Centre National de Recherche pour le Développement (CNRD), N'Djaména, Tchad · 3 - Centre Français des Études Éthiopiennes (CFEE), CNRS & Ministère de l'Europe et des Affaires étrangères, Addis-Abeba, Éthiopie · 4 - Faculté des Sciences Exactes et Appliquées, Université de N'Djaména, N'Djaména, Tchad · 5 - Académie de l'Éducation Nationale du Nord (Faya), N'Djaména, Tchad · 6 – Université Polytechnique de Mongo – Mongo, Tchad

Toros-Menalla (TM), located in northern Chad and dated to approximately 7 million years ago, is known for its rich vertebrate assemblage, including *Sabelanthropus tchadensis*, the oldest known member of the human family and the earliest species to exhibit traits associated with bipedalism. Reconstructing the paleoenvironments of TM is essential to improving our understanding of the context in which this key locomotor adaptation emerged. Among the faunal remains, bovid astragali are particularly abundant and can serve as ecological proxies for estimating past vegetation cover [1].

To understand paleoenvironmental dynamics at TM, we conducted a 3D geometric morphometric analysis of bovid astragali. A reference dataset of 227 astragali from 64 extant African bovid species was compiled from various museum collections (Muséum national d'Histoire naturelle, Paris (MNHN); Royal Museum for Central Africa, Tervuren (RMCA); Museum für Naturkunde, Berlin (MfN); Smithsonian National Museum of Natural History, Washington DC (USNM)), representing a broad ecological and behavioural spectrum. Fossil material consisted of 237 astragali from the TM fossiliferous area, curated at the Centre National de la Recherche pour le Développement in N'Djaména. All specimens were digitized using an Artec Spider scanner. A preliminary exploration of shape variation was conducted using Deformetrica 4 [2], a software framework that analyses full mesh geometry through a landmark-free diffeomorphic deformations (DD) approach, allowing for global assessment of shape differences. However, Deformetrica was not easily applicable to fossil specimens due to their varying states of preservation. Therefore, we placed 37 original homologous 3D landmarks on each mesh, based on this preliminary analysis and the literature. This approach allowed us to incorporate fossil specimens with varying states of preservation by estimating missing landmarks through thin-plate spline interpolation, using the closest extant morphological analogs as a reference. We tested the influence of body size and habitat on astragalus shape in extant specimens, both within and outside a phylogenetic context, using multivariate approaches (MANCOVA and PGLS). We performed a Canonical Variates Analysis (CVA) on the extant dataset to distinguish astragalus shape according to four vegetation categories: Forest (F), Heavy Cover (HC), Low Cover (LC), and Open (O). Discriminant functions derived from these data were then applied to classify the fossil specimens.

Our results show statistically significant morphological differences among vegetation types, based on Mahalanobis distances from permutation tests, validating previous morphofunctional predictions. Fossil astragali from TM indicate a heterogeneous landscape, with assemblages ranging from sparsely vegetated zones to areas consistent with more forested cover. These findings suggest ecological diversity at TM, supporting a complex habitat model [3]. Our study shows environmental heterogeneity within the TM fossiliferous area. Further integration with geological and biogeochemical data will provide a refined ecological framework, a crucial step for understanding the ecosystem dynamics that may have favored early hominin emergence.

I would like to thank the Nouvelle-Aquitaine Region and the Grand Poitiers Urban Community for funding this study. I am also grateful to the following institutions for welcoming me and granting access to their collections: the Muséum national d'Histoire naturelle in Paris (MNHN), the Royal Museum for Central Africa in Tervuren (RMCA), and the Museum für Naturkunde in Berlin (MfN), the Centre de Recherche et de Développement in Chad. I sincerely thank W. Andrew Barr and the members of the PAPER Lab at The George Washington University for sharing their data collection. I also extend my gratitude to the Division of Mammals at the United States National Museum of Natural History for providing access to specimens.

References: [1] Barr, W.A., 2015. Paleoenvironments of the Shungura Formation (Plio-Pleistocene: Ethiopia) based on ecomorphology of the bovid astragalus. *Journal of Human Evolution*. 88, 97–107. [2] Bône, A., Louis, M., Martin, B., Durrleman, S., 2018. Deformetrica 4: An Open-Source Software for Statistical Shape Analysis. *Shape in Medical Imaging*. 3–13. [3] Novello, A., Barboni, D., Sylvestre, F., Lebatard, A.-E., Paillés, C., Bourlés, D.L., Likius, A., Mackaye, H.T., Vignaud, P., Brunet, M., 2017. Phytoliths indicate significant arboreal cover at *Sabelanthropus* type locality TM266 in northern Chad and a decrease in later sites. *Journal of Human Evolution*. 106, 66–83.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Climate, energetics, and nasal morphology: analyzing ecogeographic variation across global populations

Alexa Kelly<sup>1</sup>, Scott Maddux<sup>2</sup>

1 - Campbell University School of Osteopathic Medicine · 2 - University of North Texas Health Science Center

**Background:** Ecogeographic variation in human nasal morphology has long been linked to environmental factors such as temperature and humidity. Populations from colder, drier climates typically exhibit narrower nasal passages, while those from warmer, more humid regions tend to have wider passages [1]. Recent studies suggest that metabolic demands, particularly in populations from the Arctic Circle, influence nasal size, with individuals having higher basal metabolic rates (BMR) also exhibiting larger nasal passages [2]. This study aims to expand on this understanding by examining the roles of both metabolic demands and climate in shaping nasal morphology across various human populations [3]. We analyzed 180 mixed-sex crania from Europe, Southeast Asia, and East, North, and Central Africa using computed tomography (CT) scans and 3D Slicer software. Three-dimensional geometric morphometric techniques were applied to the nasal skeletons to assess nasal size and shape. These data were combined with postcranial measurements obtained from skeletal elements associated with each cranium. Body mass and climate-specific BMR were then estimated using established formulae [4,5].

**Results:** T-tests revealed significant sex differences were observed for both BMR ( $p < 0.0003$ ) and nasal centroid size ( $p < 0.0001$ ) across all three geographic regions, with males consistently exhibiting higher BMRs and larger nasal passages than females. All populations demonstrated significant correlations between high BMR values and larger nasal sizes ( $p < 0.0001$ ) when regressed, except for the African group ( $p = 0.1977$ ). Further analyses examined how nasal height, length, and breadth related to energetic demands. In the European group, which largely represents temperate climates, both nasal height ( $p < 0.001$ ) and length ( $p = 0.004$ ) showed positive correlations with BMR, whereas nasal breadth did not ( $p = 0.084$ ). In contrast, in Southeast Asia, a region characterized by hot and humid conditions, nasal length was significantly correlated with BMR ( $p = -0.025$ ), while both nasal height ( $p = 0.398$ ) and breadth ( $p = 0.114$ ) were not. Similarly, in the African groups, while nasal morphology varied with climate, relatively low metabolic demand seemed to have a reduced influence on nasal features.

**Conclusion:** These findings underscore the complex relationship between climate, metabolic demands, and nasal morphology. While the physical climate appears to be the dominant factor shaping nasal structure, metabolic demands also play an important role, especially in colder regions where nasal passages are adapted to condition the air. In hotter, more humid environments, however, the selective pressure on nasal height and breadth is reduced due to lower air-conditioning demands. This lack of correlation becomes more pronounced as the climate becomes warmer (e.g., equatorial Africa). Collectively, these results offer a more nuanced understanding of human adaptation, highlighting the importance of considering both climatic and metabolic pressures in studies of nasal morphology.

Exceptional appreciation is given to the universities, museums, and repositories from which these data were gathered, namely the: University of Bordeaux, University of Coimbra, University of Hong Kong, University of Cambridge, American Museum of Natural History, Musée de l'Homme, and the Natural History Museum, Vienna. Funding for this research provided by the National Science Foundation (BSC #2050253), Wenner-Gren Foundation (#10009), and internal funding from CUSOM.

References: [1] Thomson, A., Buxton, L.H.D., 1923. Man's Nasal Index in Relation to Certain Climatic Conditions. *The Journal of the Royal Anthropological Institute of Great Britain and Ireland*. 53, 92. [2] Kelly, A.P., Ocobock, C., Butaric, L.N., Maddux, S.D., 2023. Metabolic demands and sexual dimorphism in human nasal morphology: A test of the respiratory-energetics hypothesis. *American Journal of Biological Anthropology*. 180, 453–471. [3] Bastir, M., Godoy, P., Rosas, A., 2011. Common features of sexual dimorphism in the cranial airways of different human populations. *American Journal of Physical Anthropology*. 146, 414–422. [4] Froehle, A.W., Yokley, T.R., Churchill, S.E., 2013. Energetics and the origin of modern humans. *The Origins of Modern Humans*. 285–320. [5] Ruff, C.B., 1991. Climate and body shape in hominid evolution. *Journal of Human Evolution*. 21, 81–105.

Podium Presentation, Session 9, Saturday 14:00 – 15:20

## Combined paleoproteomics and morphological evidence reveal the evolutionary history of *Meganthropus palaeojavanicus*

Jülide Kubat<sup>1,2</sup>, Clément Zanolli<sup>3</sup>, Sofwan Noerwidi<sup>4</sup>, Ioannis Patramanis<sup>5</sup>, Claire Koenig<sup>6</sup>, Ryan Paterson<sup>5</sup>, Palesa Madupe<sup>5,7</sup>, Alberto Taurozzi<sup>5</sup>, Renaud Joannes-Boyau<sup>8</sup>, Matthew M. Skinner<sup>9</sup>, Ottmar Kullmer<sup>2</sup>, Friedemann Schrenk<sup>2</sup>, Fabrice Demeter<sup>10,11</sup>, Jesper V. Olsen<sup>6</sup>, Enrico Cappellini<sup>3</sup>, Anne-Marie Bacon<sup>1</sup>

1 - Université Paris Cité, CNRS, BABEL, F-75012 Paris, France · 2 - Department of Palaeoanthropology, Senckenberg Research Institute and Natural History Museum Frankfurt, Frankfurt am Main, Germany · 3 - Globe Institute, University of Copenhagen, Copenhagen, Denmark · 4 - Novo Nordisk Foundation Center for Protein Research, Faculty of Health and Medical Sciences, University of Copenhagen, Copenhagen, Denmark · 5 - Human Evolution Research Institute (HERI), University of Cape Town, Cape Town, South Africa · 6 - Lundbeck Foundation GeoGenetics Centre, Globe Institute, University of Copenhagen, Copenhagen, Denmark · 7 - UMR 7206 Eco Anthropologie, Muséum National d'Histoire Naturelle, CNRS, Paris, France · 8 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 9 - Geoarchaeology and Archaeometry Research Group (GARG), Southern Cross GeoScience, Southern Cross University, Lismore, Australia · 10 - Research Centre for Archaeometry, National Research and Innovation Agency, Indonesia, Jakarta, Indonesia · 11 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

The Sangiran Dome in Java yielded one of the most extensive fossil records of hominids in Asia. The high morphological diversity observed in these fossils has been either associated with a high degree of variation within *H. erectus* or interpreted as evidence for a high diversity of hominid species on Java during the Pleistocene [1,2]. Recent analyses of phylogenetically-informative internal dental structures, such as the enamel-dentine junction (EDJ) [2,3], have revealed greater taxonomic diversity among Pleistocene hominids in Java than previously assumed. Studies of the EDJ suggest that multiple hominid taxa coexisted at the Sangiran Dome during the Early to Middle Pleistocene, including *H. erectus*, *Pongo* sp., and the enigmatic *Meganthropus palaeojavanicus* [2]. These findings raise key questions about the potential interactions, ecological niche, and evolutionary history of these taxa. Determining their respective position within the Hominidae family is vital for comprehending the processes of speciation, adaptation, and extinction of these hominid taxa in Southeast Asia.

To further investigate the phylogenetic relationships of the Sangiran hominids, we conducted paleoproteomic analysis and geometric morphometrics on Early Pleistocene teeth attributed to *Meganthropus* and *H. erectus*. For the paleoproteomic analysis, we employed a digestion-free extraction protocol and tandem mass spectrometry for peptide sequencing [4]. To reliably identify the peptide sequences corresponding to the retrieved MS/MS spectra, we performed both reference database-dependent and open searches using the software tools MaxQuant and pFIND [3,4]. The reference database was compiled from publicly available sources (Uniprot and NCBI) and included enamel protein sequences limited to hominid taxa. For taxa lacking available enamel protein sequences, we derived the necessary data by translating sequences from publicly accessible genomic databases [5]. Protein sequences were aligned with MAFFT v.7 and concatenated into four final alignments, one per fossil sample. Phylogenetic analyses were conducted using MrBayes, RevBayes, and PhyML to ensure methodological robustness [3]. For the geometric morphometric analysis, we employed diffeomorphic surface matching to analyze the EDJ shape of molars. The comparative dataset includes species of *Australopithecus* (*A. afarensis*, *A. africanus*), *Paranthropus* (*P. boisei*, *P. robustus*), and Early to Middle Pleistocene *Homo* (*H. habilis*, *H. ergaster* and *H. erectus*).

Ancient peptides were successfully recovered from dental enamel, despite the open-air tropical conditions at the Sangiran Dome, which are typically challenging for protein preservation. Phylogenetic analyses of the resulting protein sequences showed that both *Meganthropus* and *H. erectus* fall within the Homininae subfamily with high support, clustering them distinctly from *Pongo*. Results of the EDJ shape analyses confirm that *H. erectus* molars from Sangiran fall within the range of variation of *H. erectus*/*H. ergaster*. In contrast, *Meganthropus* clusters in the morphospace shared by *Australopithecus* and *H. habilis* and statistically differs from the shapes of *H. erectus*/*H. ergaster* and *Paranthropus*.

These results provide new insights into the phylogenetic position of *Meganthropus*, challenging traditional assumptions about Southeast Asian hominid evolution and raising further questions about its links to early members of the *Homo* lineage or even to *Australopithecus*. As proteomic datasets expand and more fossil material is analyzed, integrating molecular data with geometric morphometrics will provide a more comprehensive framework for reevaluating hominid diversity, adaptation, evolution, and biogeography in Pleistocene Southeast Asia.

Werner Reimers Foundation in Bad Homburg, Senckenberg Research Institute and Natural History Museum Frankfurt. Research funded by: European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie 'PUSHH' grant (agreement 861389), CNRS (UMR8045 BABEL), Université Paris Cité (Program G.E.N.E Mentor), ANR GenoMorph (ANR-20-CE12-0018).

References: [1] Grine, F.E., Franzen, J. L., 1994. Fossil hominid teeth from the Sangiran Dome (Java, Indonesia). *Courier Forschungsinstitut Senckenberg*, 171, 75–103. [2] Zanolli, C., Kullmer, O., Kelley, J., Bacon, A.M., Demeter, F., Dumoncel, J., Fiorenza, L., Grine, F.E., Hublin, J.J., Anh Tuan, N., Thi Mai Huong, N., Pan, L., Schillinger, B., Schrenk, F., Skinner, M.M., Ji, X., Macchiarelli, R., 2019. Evidence for increased hominid diversity in the Early-Middle Pleistocene of Indonesia. *Nature Ecology and Evolution*, 3, 755–764. [3] Kubat, J., Paterson, R., Patramanis, I., Barker, G., Demeter, F., Filoux, A., Kullmer, O., Mackie, M., Marques-Bonet, T., Thi Mai Huong, N., Anh Tuan, N., Pheng, S., Rippengal, J., Schrenk, F., Souksavatdy, V., Tshen, L.T., Wattanapitaksakul, A., Wang, W., Zanolli, C., Cappellini, E., Bacon, A.M., 2023. Geometric morphometrics and paleoproteomics enlighten the palaeodiversity of *Pongo*. *PLoS One*, 18, e0291308. [4] Madupe, P.P., Munir, F., Dickinson, M. Taurozzi,

A.J., Mackie, M., Tawane, M., Mollereau, C., Hlazo, N., Penkman, K., Schroeder, L., Zanolli, C., Olsen, J.V., Ackermann, R.R., Cappellini, E., 2025. Results from an *Australopithecus africanus* dental enamel fragment confirm the potential of palaeoproteomics for South African Plio-Pleistocene fossil sites. *South African Journal of Science*. 121, 18571. [5] Patramanis, I., Madrigal, J.R., Cappellini, E., Racimo, F., 2023. PaleoProPhyler: a reproducible pipeline for phylogenetic inference using ancient proteins. *Peer Community Journal*, 3.

Poster Presentation Number 83, Session 1, Thursday 14:00 - 15:30

## Refining the cognitive demands for Acheulean handaxe productions using Petri net process modelling

Jesse Kuijt<sup>1</sup>, Sebastian Fajardo<sup>2</sup>, and Marie Soressi<sup>1</sup>

1 - Faculty of Archaeology, Leiden University · 2 - Leiden Inst of Advanced Computer Science, Leiden University

Chipped stone tools are among the most valuable indirect sources for reconstructing the evolution of hominin cognition. As the oldest, most enduring, and most widely distributed technology in the archaeological record, they offer key insights into technological change over time. Increases in cutting edge production rates and total edge length throughout the Pleistocene have been interpreted as evidence of improved efficiency [1,2]. More recently, Paige and Perreault [3] examined lithic technological complexity by counting procedural units in toolmaking processes over time. They observed that complexity increased considerably only after ~600 kya—later than previously assumed—and argued that this shift marks the onset of cumulative culture in the Middle Pleistocene. However, while procedural unit counts provide a useful metric, it remains unclear what cognitive aspect of complexity they truly reflect.

To explore this further, we apply Petri nets, a modelling tool from computer science, to chipped stone tool production. Petri nets enable a multifaceted analysis of procedural complexity. Fajardo et al. [4] first introduced this approach in archaeology to model birch tar adhesive production. Building on their work, we tested whether Petri net complexity metrics could inform our understanding about cognitive demands of knapping.

Two knappers with differing experience levels produced seven experimental sequences:

- Two Early Acheulean handaxes with stone hammers,
- Two Late Acheulean handaxes with stone hammers,
- Three Late Acheulean handaxes with both stone and antler hammers.

Each knapping session was video-recorded and used to construct Petri nets. Where necessary, models were refined through discussions with the knappers. We then applied three structural complexity metrics [after 4]:

1. Interconnectedness of elements,
2. Decision-making uncertainty, and
3. Understandability of design patterns.

These metrics have previously been interpreted as proxies for cognitive abilities such as information processing, inhibitory control, and learnability. We also measured a standard efficiency metric: cutting edge-to-weight ratio for flakes >2 cm.

Key findings:

1. Interconnectedness of elements was slightly lower in Early Acheulean than Late Acheulean with stone hammers, but lowest in Late Acheulean with both stone and antler hammers—indicating lower simultaneous information load in the latter.
2. Decision-making: Early Acheulean had one fewer decision point than Late Acheulean with stone hammers, and considerably fewer than when both hammer types were used. The additional hammer appears to increase potential for errors from decision making, thus inducing more uncertainty.
3. Design understandability: Early Acheulean design patterns were harder to interpret than Late Acheulean with stone hammers; the Late Acheulean with dual hammer use showed the least understandable patterns.
4. Efficiency: Late Acheulean techniques produced higher cutting edge-to-weight ratios for flakes >2 cm. For flakes >3.5 cm, only sequences involving both stone and antler hammers showed improved efficiency.

Our results suggest that the most pronounced shift in Acheulean cognitive complexity occurred with the introduction of antler hammers and aligns with the proposed rise in lithic complexity around ~600 kya [3]. This suggested shift specifically took place in metrics implicated with increasing uncertainty and reduced learnability, thereby drawing a parallel to the open-ended quality of human cumulative culture proposed by Mesoudi and Thornton [5]. Future work can benefit from more refined complexity definitions to pinpoint the drivers of technological change in the Middle Pleistocene.

References: [1] Muller, A., Clarkson, C., 2016. Identifying major transitions in the evolution of lithic cutting edge production rates. *PLOS ONE*. 11, e0167244. [2] Režek, Ž., Dibble, H.L., McPherron, S.P., Braun, D.R., Lin, S.C., 2018. Two million years of flaking stone and the evolutionary efficiency of stone tool technology. *Nature Ecology & Evolution*. 2, 628–633. [3] Paige, J., Perreault, C., 2024. 3.3 million years of stone tool complexity suggests that cumulative culture began during the Middle Pleistocene. *Proceedings of the National Academy of Sciences*. 121. [4] Fajardo, S., Kozowyk, P.R.B., Langejans, G.H.J., 2023. Measuring ancient technological complexity and its cognitive implications using Petri nets. *Scientific Reports*. 13. [5] Mesoudi, A., Thornton, A., 2018. What is cumulative cultural evolution? *Proceedings of the Royal Society B: Biological Sciences*. 285, 20180712.

Poster Presentation Number 84, Session 1, Thursday 14:00 - 15:30

## Ontological disparities in definitions of the human across archaeology, paleoanthropology, and paleogenetics

Karel J. Kuipers<sup>1,2</sup>, Julien Kloeg<sup>2</sup>

1 - University of Leiden · 2 - Erasmus University of Rotterdam

The field of Human Evolution is explicitly interdisciplinary. Historically, paleoanthropology and archaeology have shared a research tradition focused on human origins. Yet their respective emphases—on hominin skeletal remains and on material artefacts—have led to divergent terminologies when defining concepts such as ‘modernity’ and ‘human’. In recent years, Paleogenetics has rapidly emerged from microbiology as a fully-fledged subdiscipline, introducing a third discourse with its own set of conceptualizations. This growing plurality has complicated the development of a unified theoretical framework. Despite—or perhaps because of—significant methodological and empirical progress over the past two decades, fundamental concepts in human evolution remain contested. In this contribution, we present a critical synthesis of relevant literature and identify three dominant discourses, each rooted in distinct research traditions.

First, the genetic discourse defines modern humans in terms of ancestry, typically the ‘modern human’ to African-derived genetic lineages. Second, the physical anthropological discourse defines the anatomically modern human – or modern morphologies of the *Homo sapiens* lineage - using statistical norms derived from present-day skeletal variation. Third, the archaeological discourse defines modernity through behavioral markers such as symbolic behavior. These divergent conceptualizations invite categorical inconsistencies that likely hamper the development of a unified framework—particularly in interdisciplinary contexts. Without ontological coherence, the field risks theoretical fragmentation and limits the comparability of results across subfields. We contend that Human Evolution, while empirically rich, remains theoretically underdeveloped.

In particular, we suggest the field would benefit from a more serious engagement with philosophical anthropology, which addresses the foundational question: *What constitutes a human being?* While *Human Evolution* has made great strides in answering the *diachronic question*—*How did we become what we are?*—it continues to struggle with the *synchronic question*: *What are we?* Though this may appear to be a semantic issue, it is fundamentally ontological. Working definitions are too often treated as final, mutually exclusive commitments, rather than as provisional tools to guide inquiry. This leads to divergent—and sometimes incompatible—answers to core questions about human evolution and human nature.

We advocate turning to non-reductive philosophical anthropologists such as Helmuth Plessner, whose relational and multiscale framework avoids both naturalistic reductionism and rigid typological thinking. By reframing the human through a philosophy of nature, such perspectives may offer a path toward conceptual synthesis across disciplines.

We would like to thank Marie Soressi for helpful comments and suggestions

Poster Presentation Number 85, Session 1, Thursday 14:00 - 15:30

## Investigating stress proteins in teeth to characterize physiological and environmental stressors in Neolithic societies

Mona Le Luyer<sup>1</sup>, Katell Bathany<sup>2</sup>, Caroline Tokarski<sup>2</sup>, Stéphane Rottier<sup>1</sup>, Priscilla Bayle<sup>1</sup>

1 - Univ. Bordeaux, CNRS, Ministère de la Culture, PACEA, UMR 5199, Pessac, France · 2 - Univ. Bordeaux, CNRS, Bordeaux INP, CBMN, UMR 5248, and Bordeaux Proteome Platform, Bordeaux, France

The Neolithic transition introduced major shifts in critical aspects of human evolution: socio-economy, culture, biology, demography, and epidemiology [1]. Among the major modifications observed, the Neolithic agricultural revolution is associated with a change in diet and cooking practices; a decrease in human stature, robustness, and teeth dimensions; an increased population density; an overall deterioration in health conditions, including a higher prevalence of pathologies, physiological stress, and growth disturbances [1-2]. However, this major toll on human health has been evaluated by non-specific indicators of stress, and it is unclear which stressors might be responsible for all the physiological and health shifts observed in Neolithic human populations. Here we are using an approach combining histology and proteomics to investigate stress proteins in teeth, with the aim to identify and quantify specific stress responses at the molecular level.

After preliminary tests on one clinically extracted tooth and one archaeological tooth, we selected 6 molars belonging to 6 humans for whom we know the sex and the kinship. We sampled 3 contemporary individuals – 2 siblings (one male and one female) and one non-related individual – from the Tooth Fairy collection [3], a reference sample with known information about individuals' life-history events. And we selected 3 Neolithic individuals – 2 siblings (both females) from pedigree A, and one non-related male individual – from the necropolis of Gurgy [4], a past community with precise data on living conditions (diet, health, etc.) and social structure.

Dental thin sections were used to identify the accentuated lines and to quantify the frequency of stress lived by each individual. As minimally invasive as possible, samples were taken from the remaining parts of the teeth left after histological sectioning. Proteomics workflow involving a bottom-up strategy was used to evaluate stress proteins: heat shock protein-70 (HSP70), expressed in response to stress and particularly sensitive to physiological and external environmental stressors; and C-reactive protein (CRP), secreted in response to inflammation and infection.

For each individual, a various number of stress events were identified on the dental thin sections. Stress proteins, were identified in both contemporary and archaeological individuals using proteomics. For each tooth, the detection of stress proteins was confronted with the differential quantities of stress events recorded on histological data.

Deciduous and permanent teeth offer the possibility to evaluate stressors experienced by an individual from in-utero to childhood and adolescence. During their formation, dental tissues record both physiological and psychopathological disturbances that are visible in microscopy in the form of accentuated lines. With the exception of the neonatal line indicating the moment of birth, the cause of these accentuated lines cannot be specified for past individuals. The analyses of stress proteins offer the possibility to specify the type of stress. To our knowledge, the detection of the presence of these proteins has been only assessed in teeth from living individuals and Native Americans from the late 19th century [5]. Using this innovative approach to characterize stress proteins in Neolithic individuals will allow to identify the specific stressors having affected human life and health at the beginning of farming.

This study received financial support from the French government in the framework of the University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past". Dental thin sections were obtained with the support of the FYSSSEN Foundation (to M. Le Luyer) and the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie actions (REDUCTeeth, MSCA-IF-2017-796499, to M. Le Luyer).

References: [1] Pinhasi, R., Stock, J.T. (Eds.), 2011. *Human Bioarchaeology of the Transition to Agriculture*. John Wiley & Sons, Ltd. [2] Marciniak, S., Bergey, C.M., Silva, A.M., Haluszko, A., Furmanek, M., Veselka, B., Velemínský, P., Vercellotti, G., Wahl, J., Zariwa, G., Longhi, C., Kolář, J., Garrido-Pena, R., Flores-Fernández, R., Herrero-Corral, A.M., Simalszik, A., Müller, W., Sheridan, A., Miliuskiene, Ž., Jankauskas, R., Moiseyev, V., Köhler, K., Király, Á., Gamarra, B., Cheronet, O., Szeverényi, V., Kiss, V., Szeniczey, T., Kiss, K., Zoffmann, Z.K., Koós, J., Hellebrandt, M., Maier, R.M., Domboróczki, L., Virag, C., Novak, M., Reich, D., Hajdu, T., von Cramon-Taubadel, N., Pinhasi, R., Perry, G.H., 2022. An integrative skeletal and paleogenomic analysis of stature variation suggests relatively reduced health for early European farmers. *Proceedings of the National Academy of Sciences*. 119. [3] Le Luyer, M., Bayle, P., 2021. The Tooth Fairy collection (a collection Petite souris), a sample of documented human deciduous teeth at the University of Bordeaux, France. *American Journal of Biological Anthropology*. 177, 175–181. [4] Rivollat, M., Rohrlach, A.B., Ringbauer, H., Childebayeva, A., Mendisco, F., Barquera, R., Szolek, A., Le Roy, M., Collieran, H., Tuke, J., Aron, F., Pemonge, M.-H., Späth, E., Télouk, P., Rey, L., Goude, G., Balter, V., Krause, J., Rottier, S., Deguilloux, M.-F., Haak, W., 2023. Extensive pedigrees reveal the social organization of a Neolithic community. *Nature*. 620, 600–606. [5] Buonasera, T., Eerkens, J., Malarchik, D., Panich, L.M., Canzonieri, C., Zimmer, C., Clough, C., Ostrander, T., Sutton, A., Salemi, M., Parker, G., 2024. Immune proteins recovered in tooth enamel as a biochemical record of health in past populations: Paleoproteomic analysis of Mission Period Native Californians. *Journal of Archaeological Science*. 171, 106069.

Poster Presentation Number 86, Session 2, Friday 14:00 - 15:30

## Trophic structure of the hominin-bearing deposits Makapansgat and Swartkrans in South Africa based on novel stable isotope analyses

Jennifer Leichliter<sup>1,2</sup>, Marissa Vink<sup>1</sup>, Hubert Vonhof<sup>3</sup>, Lazarus Kgasi<sup>4,7</sup>, Dominic Stratford<sup>5,6</sup>, Marion Bamford<sup>2</sup>, Alfredo Martinez-Garcia<sup>3</sup>, Tina Lüdecke<sup>1,2</sup>

1 - Emmy Noether Group for Hominin Meat Consumption, Max Planck Institute for Chemistry, Mainz, Germany · 2 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa · 3 - Department for Climate Geochemistry, Max Planck Institute for Chemistry, Mainz, Germany · 4 - Department of Paleontology, Ditsong National Museum of Natural History, Pretoria, South Africa · 5 - School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa · 6 - Department of Anthropology, Stony Brook University, Stony Brook, New York · 7 Palaeo-Research Institute, University of Johannesburg, Johannesburg, South Africa

Dietary changes, specifically the incorporation of animal resources, are hypothesized to have played a pivotal role in early hominin evolution. However, reconstructing ancient food webs, and the position of hominins within them, remains challenging. Here, we present enamel isotope data to evaluate the diets of Plio-Pleistocene fauna from Makapansgat Limeworks (Member 3; ~3.0 to 2.6 Ma; yielding *Australopithecus africanus*) and Swartkrans Cave (Members 1-3; ~2.2 to 0.8 Ma; yielding *Paranthropus robustus* and *Homo* sp.).

Stable carbon ( $\delta^{13}\text{C}_{\text{enamel}}$ ), nitrogen ( $\delta^{15}\text{N}_{\text{enamel}}$ ), and oxygen ( $\delta^{18}\text{O}_{\text{enamel}}$ ) isotopes were measured in the organic (N) and inorganic (C and O) fractions of enamel (ca. 5 mg) from fossil teeth belonging to representative carnivore, omnivore, and herbivore (browsers, grazers, mixed feeders) specimens from each locality. We observe good preservation of organic matter in fossil tooth enamel (N content  $x=2.9 \pm 1.0$  nmol/mg), and clear trophic separation in  $\delta^{15}\text{N}_{\text{enamel}}$  values. Carnivores are significantly enriched in the heavy isotope of nitrogen compared to herbivores at both Makapansgat ( $\delta^{15}\text{N}_{\text{carnivore-herbivore}}=3.2\text{‰}$ ) and Swartkrans ( $\delta^{15}\text{N}_{\text{carnivore-herbivore}}=4.4\text{‰}$ ), which is expected as a result of their higher trophic level. Suid  $\delta^{15}\text{N}_{\text{enamel}}$  values ( $x=8.9$  ‰) are intermediate to those of herbivores and carnivores at Makapansgat (no suids were available for sampling at Swartkrans), reflecting potential omnivory. Overall, the observed enrichment between trophic levels falls within the typical range of 3 to 6‰ documented between diet and consumer in modern and fossil ecosystems (e.g., [1-5]). A range of C3-C4 dietary resource use is represented in the faunal  $\delta^{13}\text{C}_{\text{enamel}}$  values, with herbivores showing a clear separation between browsers and grazers, while mixed feeders exhibit variable values reflecting their consumption of both plant types. Carnivore  $\delta^{13}\text{C}_{\text{enamel}}$  are intermediate and indicate that predators fed on a mix of prey species at both sites. Suids at Makapansgat consumed primarily C4 resources ( $x=-1.8\text{‰}$ ). Herbivore and carnivore  $\delta^{18}\text{O}_{\text{enamel}}$  values are less variable at Swartkrans (-4.3 to 1.9‰) compared to Makapansgat (-7.7 to 3.1‰), possibly indicating use of a shared local water source by most fauna at Swartkrans (e.g., nearby Blaaubank River).

These well-constrained isotopic baselines for Swartkrans and Makapansgat provide critical context for the interpretation of primate isotope values and will allow us to directly situate the dietary niches of specific hominins within their ancient food webs.

This study was funded by the Deutsche Forschungsgemeinschaft (DFG) Emmy Noether Fellowship LU 2199/2-1 to TL, and by the Max Planck Society (MPG).

References: [1] Bocherens, H., Drucker, D., 2003. Trophic level isotopic enrichment of carbon and nitrogen in bone collagen: Case studies from recent and ancient terrestrial ecosystems. *International Journal of Osteoarchaeology*. 13, 46-53. [2] Caut, S., Angulo, E., Courchamp, F., 2009. Variation in discrimination factors ( $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$ ): The effect of diet isotopic values and applications for diet reconstruction. *Journal of Applied Ecology*. 46, 443-453. [3] Leichliter, J.N., Lüdecke, T., Foreman, A.D., Bourgon, N., Duprey, N.N., Vonhof, H., Soukavaty, V., Bacon, A.-M., Sigman, D.M., Tütken, T., Martínez-García, A., 2023. Tooth enamel nitrogen isotope composition records trophic position: a tool for reconstructing food webs. *Communications Biology*. 6, 373. [4] Leichliter, J.N., Lüdecke, T., Foreman, A.D., Duprey, N.N., Winkler, D.E., Kast, E.R., Vonhof, H., Sigman, D.M., Haug, G.H., Clauss, M., Tütken, T., Martínez-García, A., 2021. Nitrogen isotopes in tooth enamel record diet and trophic level enrichment: Results from a controlled feeding experiment. *Chemical Geology*. 563, 120047-120047. [5] Schoeninger, M.J., DeNiro, M.J., 1984. Nitrogen and carbon isotopic composition of bone collagen from marine and terrestrial animals. *Geochimica et Cosmochimica Acta*. 48, 625-639.

Poster Presentation Number 87, Session 2, Friday 14:00 - 15:30

## From anatomical modernity to evolutionary complexity: rethinking human variation beyond a binary framework

Mathilde Lequin<sup>1</sup>, Priscilla Bayle<sup>1</sup>, Thomas Colard<sup>1,2</sup>, Quentin Cosnefroy<sup>1</sup>, Isabelle Crevecœur<sup>1</sup>, Francesco D'Errico<sup>1,3</sup>, Luc Doyon<sup>1</sup>, Adeline Le Cabec<sup>1,4</sup>, Diego López Onaindia<sup>1</sup>, Bruno Maureille<sup>1</sup>, Antoine Souron<sup>1</sup>, Christine Veschambre-Couture<sup>1</sup>, Clément Zanolli<sup>1,5</sup>

1 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France · 2 - Univ. Lille, CHU Lille, Department of Oral and Maxillofacial Radiology, Lille, France · 3 - Centre for Early Sapiens Behaviour, Department of Archaeology, History, Cultural Studies and Religion, University of Bergen, Norway · 4 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 5 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa

The concept of anatomical modernity has been widely used in paleoanthropology to describe fossil specimens exhibiting derived traits shared with extant humans. This categorization generally contrasts “anatomically modern humans” (AMH) with “archaic” groups such as Neanderthals and Denisovans. While the notion of “behavioral modernity” has undergone significant critical examination [1], its anatomical counterpart has received comparatively less scrutiny (but see [2-3]).

Here, we propose a critical reassessment of the concept of anatomical modernity, bridging paleoanthropology and epistemology to examine the assumptions embedded in this category and its implications for interpreting the fossil record. Although often presented as a neutral descriptive term, we argue that the label “AMH” is conceptually problematic and impacts both classification practices and evolutionary narratives—particularly as it becomes increasingly conflated with notions of genetic modernity.

We address three key issues. First, we show that there is no consensus regarding which past populations fall under the label of AMH, or on the defining traits of anatomical modernity. Second, we interrogate the common equivalence between AMH and *Homo sapiens*, noting that AMH may represent only a subset of this species, and we investigate how this equivalence impacts interpretations of the fossil record. Third, we examine the issues pertaining to the qualitative label of modernity by addressing the limitations of the “modern” versus “archaic” dichotomy—a binary framework that inadequately captures the biological and cultural complexity within *Homo sapiens* and across other hominin groups.

We conclude that the category of anatomical modernity is not relevant and should be abandoned. In its place, we advocate for a revised nomenclature grounded in a quantitative framework that integrates phenotypic variability and contextualizes it within defined chronological horizons, offering a more accurate reflection of the evolutionary diversity within our species.

This study received financial support from the French government in the framework of the University of Bordeaux's IdEx 'Investments for the Future' program/GPR 'Human Past'.

Reference: [1] Meneganzin, A., Currie, A., 2022. Behavioural modernity, investigative disintegration & Rubicon expectation. *Synthese*. 200. [2] Pearson, O.M., 2008. Statistical and biological definitions of “anatomically modern” humans: Suggestions for a unified approach to modern morphology. *Evolutionary Anthropology: Issues, News, and Reviews*. 17, 38–48. [3] Kissel, M., Fuentes, A., 2021. The ripples of modernity: How we can extend paleoanthropology with the extended evolutionary synthesis. *Evolutionary Anthropology: Issues, News, and Reviews*. 30, 84–98.

Poster Presentation Number 88, Session 2, Friday 14:00 - 15:30

## Medial epicondylar lesions in Neandertals: a topographical approach to throwing-related activity and engendered labour

Elle B.K. Liagre<sup>1</sup>, Christopher J. Knüsel<sup>1</sup>, Sébastien Villotte<sup>2,3,4</sup>

1 - UMR5199 PACEA, CNRS, MCC, Université de Bordeaux, Pessac, France · 2 - UMR7206 Éco-Anthropologie, CNRS, MNHN, Université Paris Cité. Musée de l'Homme, Paris, France · 3 - Quaternary environments & Humans, OD Earth and History of life, Royal Belgian Institute of Natural Sciences, Brussels, Belgium · 4 - Unité de Recherches Art, Archéologie Patrimoine, Université de Liège, Liège, Belgium

Gender roles are dynamic social constructs that vary across cultures and time, yet often display recurring patterns, particularly in subsistence activities, resource exploitation, and sharing. Ethnographic and archaeological evidence shows marked variability in the sexual division of labour among hunter-gatherers, although male predominance in big-game hunting remains a near-universal feature. These patterns have prompted comparisons between Neandertals and Anatomically Modern Humans, with the former often characterised by group-based hunting of large prey and the latter associated with more diversified subsistence strategies and a pronounced division of labour [1].

These behavioural distinctions are further underscored by debates surrounding the emergence of long-distance projectile use, with some arguing that anatomical adaptations for throwing, such as humeral torsion and requisite shoulder morphology, are more pronounced in Anatomically Modern Humans than in Neandertals [2]. Such osteological differences have been interpreted as evidence of divergent hunting strategies and levels of task specialisation between the two groups. However, direct evidence of such behavioural differences remains scarce. In this context, medial epicondylar enthesal lesions, including avulsion fractures, provide a unique window into past behaviours. Drawing on comparisons with clinical medical research (e.g. [3]), these enthesal changes are likely linked to repetitive or forceful motions, which may include activities such as overhead throwing of objects and stone tool crafting [4-5].

We present a novel, non-invasive protocol to examine the attachment site of the medial collateral ligament in Neandertal humeri using 3D imaging. Our methodology combines imaging filters, in particular ambient occlusion techniques, with topographical surface analysis to objectively identify and characterise lesions. This protocol was developed and validated through the analysis of archaeological samples from France and Belgium that included identified cases of medial epicondylar partial avulsion injuries [5].

Preliminary findings revealed a relatively high occurrence of lesions, predominantly unilateral, in our Neandertal sample. This pattern may point to repetitive, asymmetric upper-limb use consistent with throwing-related stress. Although sample size remains a limiting factor, these results provide fresh evidence for discussions on activity patterns and labour organisation in past hominin groups, challenging long-standing assumptions about Neandertal technological and social complexity. This highlights the potential of skeletal microtrauma as a valuable proxy for activity patterns and offers a novel line of evidence for re-assessing behavioural variability and role specialisation in Neandertal groups.

This study received financial support from the French government in the framework of the University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past", as well as the Département des Sciences Archéologiques de Bordeaux. For access to the specimens and 3D data, we would like to thank the Muséum national d'Histoire naturelle in Paris, France (F. Detroit, D. Grimaud-Hervé, L. Huet, V. Laborde, A. Thomas), the Royal Belgian Institute of Natural Sciences in Brussels, France (C. Polet, P. Semal), the Smithsonian Human Origins Program (USA), B. Maucille (University of Bordeaux, France), C. Couture-Verschambre (University of Bordeaux, France), R. Macchiarelli (University of Poitiers, France), and A. Rosas (National Museum of Natural Sciences, Madrid, Spain).

References: [1] Kuhn, S.L., Stiner, M.C., 2006. What's a mother to Do? *Current Anthropology*. 47, 953–981. [2] Rhodes, J.A., Churchill, S.E., 2009. Throwing in the Middle and Upper Palaeolithic: inferences from an analysis of humeral retroversion. *Journal of Human Evolution*. 56, 1–10. [3] Patel, R.M., Lynch, T.S., Amin, N.H., Calabrese, G., Gryzlo, S.M., Schickendantz, M.S., 2014. The Thrower's Elbow. *Orthopedic Clinics of North America*. 45, 355–376. [4] Knüsel, C.J., 1992. The throwing hypothesis and hominid origins. *Human Evolution*. 7, 1–7. [5] Polet, C., Martiarena, M.L., Villotte, S., Vercauteren, M., 2019. Throwing activities among Neolithic Populations from the Meuse River Basin (Belgium, 4500–2500 BC) with a focus on adolescents. *Childhood in the Past*. 12, 81–95.

Poster Presentation Number 89, Session 2, Friday 14:00 - 15:30

## **Patterns of dental growth and growth disruption in Neanderthals and Upper Paleolithic modern humans: a 3D study of linear enamel hypoplasia**

**Laura S. Limmer<sup>1,2</sup>, Kate McGrath<sup>3,4</sup>, Katerina Harvati<sup>1,2</sup>, Sireen El Zaatari<sup>1,2</sup>**

1 - Paleoanthropology, Senckenberg Centre for Human Evolution and Palaeoenvironment, Institute of Archaeological Sciences, University of Tübingen, Germany · 2 - DFG Center of Advanced Studies 'Words, Bones, Genes, Tools: Tracking linguistic, cultural and biological trajectories of the human past', University of Tübingen, Germany · 3 - Department of Anthropology, Center for the Advanced Study of Human Paleobiology, The George Washington University, Washington, DC, USA · 4 - CENIEH, Burgos, Spain

Malnutrition, diseases, and other physiological stressors can interrupt dental enamel formation and manifest as hypoplastic defects on the enamel surface. These defects, particularly in their linear form, i.e., linear enamel hypoplasia (LEH), have been used as stress markers in clinical and archaeological samples. LEH prevalence, width, and depth have been used to track and compare frequencies of stress episodes, their duration, and severity within and across populations. However, with recent studies revealing more complex interactions between LEH expression and intrinsic enamel growth patterns, the validity of using LEH defects as trackers for physiological stress in direct cross-taxa comparisons without considering intrinsic growth patterns might be questionable.

Here, we examine the interaction between surface manifestations of regular enamel growth (perikymata) and linear hypoplastic disruptions of growth (LEH) in a large sample of Neanderthal and Upper Paleolithic modern humans (UPMH). We assess these features in light of what is known about species-specific dental growth patterns to elucidate more about their relationship, namely what can be gleaned from the expression of perikymata and enamel defects on the dental surface.

Our sample consists of 67 anterior dentitions, including central and lateral incisors as well as canines, of Neanderthals (n=35) and Upper Paleolithic modern humans (UPMH, n=32) with well-preserved enamel surfaces and identifiable perikymata and LEH. Using 3-dimensional confocal profilometry, we quantify perikymata spacing and dimensions (widths and depths) across the different tooth types in each hominin group and compare them between the two groups. We also measure the dimensions (width and depth) of the identified LEH defects and calculate severity ratios by scaling their dimensions to those of the surrounding perikymata, thus controlling for tooth- and taxon-specific enamel growth patterns while comparing them between taxa.

In the sample presented here, Neanderthal anterior dentitions tend to have shallower perikymata with relatively constant vertical spacing throughout the crowns. In UPMH, perikymata are deeper and unevenly spaced across the crown lengths, with wider spacing in the cervical third of the crown. LEH depths mirror this pattern with overall shallower defects in Neanderthal teeth compared to UPMH; LEH widths showed no significant difference between the two groups. Severity width and depth ratios (defect width and depths scaled by respective regular growth features) considerably overlap between Neanderthals and UPMH.

Our non-destructive approach supports that taxon-specific differences in enamel growth influence the expression of LEH, underlining the importance of considering growth patterns when assessing enamel hypoplasia across taxa. The great overlap in severity ratios between Neanderthals and UPMH suggests that, contrary to previous studies reporting more severe stress in Neanderthals, both Paleolithic hominin groups experienced similar physiological stress levels during anterior dental development.

Poster Presentation Number 90, Session 2, Friday 14:00 - 15:30

## Morphological variation in baboon (*Papio anubis*) hand bones from the third ray in relation to arboreality

Victoria A. Lockwood<sup>1,2</sup>, Kibaliza Kimata Gilagiza<sup>3</sup>, Stephan Lihedule<sup>3</sup>, Deus Mjunga<sup>3</sup>, Anthony Collins<sup>3</sup>, Carson M. Murray<sup>2,3</sup>

1 - PALEVOPRIM: Laboratoire de Paléontologie, Evolution, Paléoécosystèmes et Paléoprimatologie, Université de Poitiers, CNRS, Poitiers, France · 2 - Department of Anthropology, Center for the Advanced Study of Human Paleobiology, The George Washington University, Washington DC, USA · 3 - Gombe Stream Research Center, Jane Goodall Institute, Kigoma, Tanzania

Investigating the nuances of the form-function relationship is key for understanding the level of behavioural resolution that can be inferred from bones. Between species variation in hand morphology is often used to provide an insight into extant and extinct primate and hominin arboreal locomotor capabilities. However, comparisons within a species provide an opportunity to minimize the confounds of phylogeny whilst assessing the effects of behavioural variation. Increased manual phalangeal indices (combined length of proximal and intermediate phalanges relative to the corresponding metacarpal) are often noted as indicators of arboreality [1], although hand use can be variable during arboreal locomotor behaviours which may complicate this relationship [2]. Olive baboons (*Papio anubis*) can inhabit a range of ecological niches [3], making them a useful species to investigate the effects of variation in arboreality on hand morphology. We collected data from three skeletal collections of *P. anubis* with differing degrees of arboreality. Free ranging relatively more arboreal baboons from the skeletal collection of The Gombe Stream Research Centre Baboon Project (Gombe National Park, Tanzania) [4], free ranging relatively more terrestrial baboons from the Smithsonian Mammal Skeletal Collection (Smithsonian National Museum of Natural History), and captive relatively more terrestrial baboons from the *Papio* Osteological Collection (Primate Station UAR 846 & UMR7194 HNHP Paris). Here we compare the phalangeal index for the third ray, given the frequent loading of the third ray during primate locomotion [5]. Only individuals with all relative bones present were included for each sample (N=10, N=3, N=4). Body mass was controlled for using the tibial proximal mediolateral breadth proxy. Whilst we predicted that the more arboreal *P. anubis* sample would have greater phalangeal indices, we found shorter phalangeal indices in the more arboreal sample compared to both relatively more terrestrial samples. We contextualized the *P. anubis* samples in a broader *Papio* sp. sample (*P. cynocephalus* and *P. ursinus*, N= 4) and the pattern was consistent. This was unexpected given the existing literature and thus suggests increased variability in arboreal associated hand bone morphology. We propose that possible differences in arboreal and terrestrial hand use and postures may explain our observed patterns. Additional morphological correlates of arboreality, such as curvature, are also being explored. Whilst formal testing of these hypotheses with an increased sample size and more detailed biomechanical and behavioural data are needed, it brings into consideration the nuances within the morphological presentations of arboreal behaviours and the impact this may have for interpreting hominin arboreal capabilities.

We would like to thank the Darrin Lunde and Ingrid Rochon for assistance with the Smithsonian Mammal Skeletal Collection, as well as Shannon Roivas and the Gombe Research Consortium. We thank Alexia Cermolacce, Gilles Berillon, Sandrine Prat, and the Primate Station UAR 846 for maintaining and providing access to the *Papio* Osteological Collection (Primate Station UAR 846 & UMR7194 HNHP Paris), as well as François Druelle for onsite assistance, and Guillaume Daver for facilitating access.

Funding for the project was provided by The Explorers Club Washington Group and the International Research Network 'Bipedal Equilibrium' (CNRS-INEE GDRI0870).

References: [1] Kirk, E.C., Lemelin, P., Hamrick, M.W., Boyer, D.M., Bloch, J.I., 2008. Intrinsic hand proportions of euarchontans and other mammals: Implications for the locomotor behavior of plesiadapiforms. *Journal of Human Evolution*. 55, 278–299. [2] Druelle, F., Young, J., Berillon, G., 2017. Behavioral implications of ontogenetic changes in intrinsic hand and foot proportions in olive baboons (*Papio anubis*). *American Journal of Physical Anthropology*. 165, 65–76. [3] Chala, D., Roos, C., Svenning, J.-C., Zinner, D., 2019. Species-specific effects of climate change on the distribution of suitable baboon habitats – Ecological niche modeling of current and Last Glacial Maximum conditions. *Journal of Human Evolution*. 132, 215–226. [4] Hunt, K.D., 1992. Positional behavior of Pan troglodytes in the Mahale Mountains and Gombe Stream National Parks, Tanzania. *American Journal of Physical Anthropology*. 87, 83–105. [5] Patel, B.A., Wunderlich, R.E., 2010. Dynamic Pressure Patterns in the Hands of Olive Baboons (*Papio anubis*) During Terrestrial Locomotion: Implications for Cercopithecoidean Primate Hand Morphology. *The Anatomical Record*. 293, 710–718.

Poster Presentation Number 91, Session 1, Thursday 14:00 - 15:30

## The legacy collection of Apidima Cave D, Peloponnese, Greece. Preliminary analysis of lithics and faunal remains

Serena Lombardo<sup>1</sup>, Effrosyni Roditi<sup>1</sup>, Nicholas C. Thompson<sup>1,2</sup>, George E. Konidaris<sup>1,3</sup>, Konstantinos Evangelou<sup>2,4</sup>, Vassilis G. Gorgoulis<sup>2,4,5,6,7</sup>, Vangelis Tourloukis<sup>1,2,8</sup>, Katerina Harvati<sup>1,2,9,10</sup>

1 - Palaeoanthropology, Institute for Archaeological Sciences and Senckenberg Centre for Human Evolution and Palaeoenvironment, Department of Geosciences, Eberhard Karls University of Tübingen, Tübingen, Germany · 2 - Museum of Anthropology, Medical School, National and Kapodistrian University of Athens, Athens, Greece · 3 - School of Geology, Aristotle University of Thessaloniki, Thessaloniki, Greece · 4 - Department of Histology and Embryology, Medical School, National and Kapodistrian University of Athens, Athens, Greece · 5 - Biomedical Research Foundation of the Academy of Athens, Athens, Greece · 6 - Ninewells Hospital and Medical School, University of Dundee, Dundee, UK · 7 - Faculty Institute for Cancer Sciences, Manchester Academic Health Sciences Centre, University of Manchester, Manchester, UK · 8 - University of Ioannina, School of Philosophy, Department of History and Archaeology, Ioannina, Greece · 9 - DFG Center for Advanced Studies 'Words, Bones, Genes, Tools', University of Tübingen, Tübingen, Germany · 10 - Centre for Early Sapiens Behaviour (SapienCE), Department of Archaeology, History, Cultural Studies and Religion, University of Bergen, Bergen, Norway

The site of Apidima (Peloponnese, Greece) is a karstic cave complex consisting of five caves (Caves A–E). Initial excavations conducted in the 1970s–80s by the Anthropological Museum of Athens uncovered paleoanthropological remains alongside a rich assemblage of lithic artefacts and faunal material dated from the Middle to the Late Pleistocene [1]. Here we present preliminary results from the ongoing re-analysis of the lithic and faunal assemblages recovered from Cave D, the uppermost cave currently situated at 24 meters above sea level. This integrated approach aimed to investigate human behaviour, technological patterns, and site use.

The analysed lithic assemblage consists of 678 artifacts. We combined attribute and reduction sequence analyses to identify flaking methods, blank selection, and retouching techniques. Approximately half of the blanks were produced on local flint, followed by radiolarite. Andesite, hematite, and other raw materials appear sporadically. Preliminary analysis of the reduction sequences indicates that bladelets and flakes were the primary production goals. Both direct percussion and bipolar on anvil techniques were employed in the knapping process, with several blanks indicating shifts between methods. Unidirectional frontal platform cores and orthogonal plane cores are exploited using both methods, while semi-tournant cores have been exclusively exploited by direct percussion for bladelet production. Additionally, debitage includes technical pieces related to the management of lateral and distal core convexities. The retouched tools are dominated by abrupt backing, with more than 67% of the tools exhibiting backed retouch. Backed bladelets are the most common type, and backed points are also present. Two specimens display very steep invasive retouch.

The as yet studied faunal collection includes 2064 specimens, of which 601 were identifiable. Taxonomic, anatomical, and taphonomic analyses (e.g., fracture patterns and bone surface modifications, such as cutmarks, percussion marks, and burning) were used to identify modifying agents and potentially infer human subsistence practices. The preliminary zooarchaeological analysis shows the dominance of avian taxa (47%), including several specimens of Phasianidae, followed by ungulates (21%), among which red deer and ibex are most common. Small-sized mammals, such as hares, were also identified (11%). Carnivorans are rare (1%), comprising fox, lynx, and a large felid. The taphonomic study shows the contribution of both humans and carnivorans as modifying agents, with gnawing marks observed mostly on birds and small-sized mammals, while cutmarks and burning indicate that humans exploited ungulates, hares, and birds. The collection also includes a rich assemblage of marine molluscs (NR=398), which, although of low taxonomic diversity, comprises predominantly edible taxa and shows characteristic fracture patterns, consistent with shellfish consumption.

Overall, the technological behaviour identified in the Cave D collection places the assemblage within the range of variability observed in the Mediterranean Gravettian/Gravettoid [2,3]. The faunal remains indicate the sporadic presence of carnivores but also evidence a broad-spectrum human diet, similar to other Upper Paleolithic sites in the region [4,5], consistent with inferences from the lithic analysis. This study underscores the value of integrated analyses, particularly for reassessing legacy collections, which often lack detailed excavation records. By combining lithic analysis with vertebrate and invertebrate evidence, we are able to provide meaningful insights into past hunter-gatherer lifeways from an otherwise limited dataset. This multidisciplinary approach provides a clearer contextual framework for future investigations at the site and contributes valuable data to the broader understanding of the Upper Paleolithic in the Peloponnese, where the archaeological record remains notably fragmentary.

References: [1] Pitsios, T.K., 1995. Paleoanthropological research at the cave site of Apidima, Laconia, Greece. *Acta Anthropologica*. 1, 1–180. [2] Kaczanowska, M., Kozłowski, J.K., Sobczyk, K., 2010. Upper Palaeolithic human occupations and material culture at Klissoura Cave 1. *Eurasian Prehistory*. 7, 133–285. [3] Litsios, P., 2024. The Gravettian of the Southern Balkans revised: The stone industries from Tripsana, Skoini 3, Skoini 4 and Melitzia caves (Mani Peninsula, Southern Greece). *Journal of Archaeological Science: Reports*. 59, 104747. [4] Darlas, A., Psathi, E., 2016. The Middle and Upper Palaeolithic on the Western Coast of the Mani Peninsula (Southern Greece). *Paleoanthropology of the Balkans and Anatolia*. 95–117. [5] Starkovich, B.M., Munro, N.D., Stiner, M.C., 2018. Terminal Pleistocene subsistence strategies and aquatic resource use in southern Greece. *Quaternary International*. 465, 162–176.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## The Middle Stone Age of the Free State (South Africa): the case of Baden-Baden 2 and Florisbad

Benoit Longet<sup>1,2</sup>, Mailys Richard<sup>1,3</sup>, Beatrice Bin<sup>1,2</sup>, Will Archer<sup>4,5,6,7</sup>, Michael B. Toffolo<sup>1,2</sup>

1 - Archéosciences Bordeaux, UMR 6034 CNRS-Bordeaux Montaigne University, France · 2 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Spain · 3 - University of Tübingen, Germany · 4 - Max Planck Partner Group, Department of Archaeology and Anthropology, National Museum, Bloemfontein, South Africa · 5 - Florisbad Quaternary Research Station, National Museum, Bloemfontein, South Africa · 6 - Department of Geology, University of the Free State, Bloemfontein, South Africa · 7 - Department of Anthropology, The George Washington University, Washington DC

The Middle Stone Age is a period spanning from >300 to 30 ka and is divided into several chronological phases, from the Early Middle Stone Age to the final MSA [1]. While the later phases of the MSA have been the focus of numerous studies detailing the diachronic development of various technocomplexes, research on the Early Middle Stone Age (EMSA) remains comparatively scarce, and definitions of EMSA technocomplexes are generally poorly characterized, particularly in the central interior of southern Africa. Nevertheless, assemblages from this early phase are of particular significance for exploring the emergence and evolution of modern humans, particularly in relation to the development of complex traits and behaviours during MIS 5.

The primary objective of this study is to develop a robust chrono-cultural reference framework for the central interior of southern Africa anchored in securely dated archaeological sequences. This study focuses geographically on the Free State region, an ecologically distinctive but under-explored area characterized by abundant yet seasonally variable freshwater resources. This ecological context likely played a pivotal role in shaping regional networks that facilitated the circulation of ideas, technological knowledge and potentially human populations throughout southern Africa.

The lithic assemblages from the sites of Baden-Baden 2 and Florisbad, which date to the terminal Middle Pleistocene and the onset of the Late Pleistocene, provide a valuable opportunity to address this research objective. Excavations conducted at Baden-Baden 2 in 2023 and 2024 yielded approximately 1,150 artefacts, distributed across three stratigraphic units and eight levels. The Florisbad assemblages comprise a collection of ~2,900 lithic artefacts (stratigraphic units P to F), recovered during fieldwork led by K. Kuman, R.J. Clarke, J.S. Brink and Z. Henderson between 1981 and 1997 [2,3]. Through a technological approach that deconstructs the operational sequences of the different assemblages [4], each site enables the definition of distinct technological entities. The site of Baden-Baden 2 reveals industries characterised by flake production from Levallois and parallel cores [5], as well as volumetric blade reductions, alongside the presence of flake-based cores (e.g. burins). Formal retouch is virtually absent. In contrast, the industries at Florisbad display several phases within the EMSA. One phase is marked by an association of elongated blanks and flakes; and a second phase characterised not only by the production of triangular blanks but also by the manufacture of blade and bladelets; obtained through volumetric core reduction and flake-based cores (e.g. burin). The two sites thus yielded assemblages that illustrate the succession of technical entities from MIS 8 to MIS 5, offering a compelling example of the complexity of these periods and underscoring the need for further investigation of this region.

The research leading to this article was conducted under the auspices of the National Museum Bloemfontein. This work was funded by the European Union (ERC, PEOPLE, project n. 101039711 to Michael Toffolo). Views and opinions expressed are however those of the author only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them. Michael Toffolo was supported also by the grant RYC2021-030917-I funded by the MCIN/AEI/10.13039/501100011033 and by the “European Union NextGenerationEU/PRTR”.

References: [1] McBrearty, S., Brooks, A.S., 2000. The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution*. 39, 453–563. [2] Kuman, K., Inbar, M., Clarke, R.J., 1999. Palaeoenvironments and cultural sequence of the Florisbad Middle Stone Age hominid site, South Africa. *Journal of Archaeological Science*. 26, 1409–1425. [3] Henderson, Z., 2001. The integrity of the Middle Stone Age horizon at Florisbad, South Africa: Background and previous work at the site. *Navorsing van die Nasionale Museum: Researches of the National Museum*. 17, 26–28. [4] Geneste, J.M., 1985. Analyse lithique d'industries moustériennes du Périgord: une approche du comportement des groupes humains au paléolithique moyen. Doctoral dissertation, Bordeaux 1. [5] Conard, N.J., Soressi, M., Parkington, J.E., Wurz, S., Yates, R., 2004. A unified lithic taxonomy based on patterns of core reduction. *South African Archaeological Bulletin*. 59, 12–16.

Poster Presentation Number 92, Session 2, Friday 14:00 - 15:30

## Hand use in technological primates: morphological signatures of stone percussive behaviours

Miguel López Cano<sup>1,2</sup>, Marine Cazenave<sup>3,4,5</sup>, Annalisa Pietrobelli<sup>3</sup>, Markus Bastir<sup>1</sup>, Tiago Falótico<sup>6,7</sup>, Tracy L. Kivell<sup>3</sup>

1 - Departamento de Paleobiología, Museo Nacional de Ciencias Naturales, Spanish National Research Council-CSIC, Madrid, Spain · 2 - Unidad de Antropología, Facultad de Ciencias Biológicas, Universidad Complutense of Madrid, Spain · 3 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 4 - Division of Anthropology, American Museum of Natural History, New York, USA · 5 - Department of Anatomy, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa · 6 - Neotropical Primates Research Group, São Paulo, Brazil · 7 - Technological Primates Research Group, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

Percussive behaviours and the resulting production of sharp-edged stone flakes have traditionally been considered hallmarks of early hominin culture. Chimpanzees, capuchin monkeys, and crab-eating macaques are the three main non-human primates in which lithic technology has been documented as part of their percussive behaviour. While the manipulative and grasping capabilities of humans and chimpanzees have been more extensively studied [1], this is not the case for the genera *Macaca* and *Sapajus*. Even less attention—mainly due to the difficulty of accessing their remains—has been given to individuals belonging to groups that certainly make use of stone tools.

This study examines whether habitual stone-percussive behaviour results in internal and external bone adaptations in hand bones by analysing high-resolution microCT and surface scans of 278 metacarpals of digits 1, 2 and 5 from technological and non-technological wild primates: *Pan troglodytes* (n=50), *Pan paniscus* (n=10), *Sapajus libidinosus* (n=4), *Sapajus apella* (n=2), *Macaca fascicularis* (n=2) and *Ptilocolobus badius* (n=12). First, we analyse external metacarpal shape using 3D geometric morphometrics (3DGM) based on a published template [2-3]. Second, we use cross-sectional geometry (CSG) of the diaphysis at three locations (25%, 50% and 75%) to assess cortical bone distribution patterns and thickness via morphomap R package [4].

Both methodologies applied suggest that stone-tool-using primates tend to exhibit differences in external bone morphology and internal bone architecture when compared to their non-tool-using counterparts; however, these differences are more pronounced between the two *Sapajus* groups than between the chimpanzee groups. 3DGM analyses reveal that the primary differences are predominantly associated with variations in relative diaphyseal width and articular surface morphology. CSG results suggest that stone-tool-using primates possess in general more robust metacarpals and greater cortical area than non-tool-using individuals. Nevertheless, there are also some differences between capuchins and chimpanzees. Among *Sapajus*, tool users do not exhibit marked shaft robustness at 25% of the first metacarpal, whereas this region shows the greatest differences between chimpanzee groups. These findings offer key insights into the skeletal adaptations linked to complex manipulative behaviours and contribute to a broader understanding of the morphological transformations associated with tool use in primates and human evolution.

We thank the following researchers or curators for access to specimens in their care: A. Lukova and M. Imbrasas (MPI-EV), M. T. Hawkins (Smithsonian MNH), E. Gilissen (MRAC), J. Cuisin (NMNH Paris), A. M. F. Oliveira Nunes (Neoprego Project), J. Stock (U. Western Ontario), A. C. A. Moura (Federal U. of Paraíba), M. M. Martinez Okumura (U. of Sao Paulo), V. Winkler (NHM Vienna), R. Wittig, C. Crockford (Tai Chimpanzee Project), I. Livne (Powell Cotton Museum), F. Mayer (NHM Berlin), Senckenberg NHM and the Bavarian Zoo. This research was supported by PID2020-115854GB-I00/MCIN/AEI/10.13039/501100011033, funded to MB by the Spanish Ministry of Science and Innovation and the European Union. MLC is supported by the Training programme for Academic Staff (FPU) contract FPU21/02087.

References: [1] Kivell, T.L., Baraki, N., Lockwood, V., Williams-Hatala, E.M., Wood, B.A., 2022. Form, function and evolution of the human hand. *American Journal of Biological Anthropology*. 181, 6–57. [2] Bastir, M., García-Martínez, D., Torres-Tamayo, N., Palancar, C.A., Fernández-Pérez, F.J., Riesco-López, A., Osborne-Márquez, P., Ávila, M., López-Gallo, P., 2019. Workflows in a Virtual Morphology Lab: 3D scanning, measuring, and printing. *Journal of Anthropological Science*. 97, 1–28. [3] Tanner, S.B., Bardo, A., Davies, T.W., Dunmore, C.J., Johnston, R.E., Owen, N.J., Kivell, T.L., Skinner, M.M., 2023. Variation and covariation of external shape and cross-sectional geometry in the human metacarpus. *American Journal of Biological Anthropology*. 183. [4] Profico, A., Bondioli, L., Raia, P., O'Higgins, P., Marchi, D., 2020. morphomap: An R package for long bone landmarking, cortical thickness, and cross-sectional geometry mapping. *American Journal of Physical Anthropology*. 174, 129–139.

Poster Presentation Number 93, Session 2, Friday 14:00 - 15:30

## Evolution and paleoecology of smart, social omnivores: Turkana suids as a model

Margot Louail<sup>1,2</sup>, Antoine Souron<sup>3</sup>, Jean-Renaud Boisserie<sup>4,5</sup>, Kevin Uno<sup>2,6</sup>

1 - The American School of Prehistoric Research, Harvard University, Cambridge, USA · 2 - Department of Human Evolutionary Biology, Harvard University, Cambridge, USA · 3 - University of Bordeaux, CNRS, Ministry of Culture, PACEA, Pessac, France · 4 - French Center for Ethiopian Studies, CNRS & Ministry of Europe and Foreign Affairs, Addis Ababa, Ethiopia · 5 - PALEVOPRIM, UMR 7262, University of Poitiers & CNRS, Poitiers, France · 6 - Department of Earth and Planetary Sciences, Harvard University, Cambridge, USA

Our understanding of environmental influences on human evolution in Africa is continuously updated by new data from the Late Pliocene and Early Pleistocene. Particularly, the Eastern African Rift System has provided evidence highlighting the importance of local environmental conditions as drivers of biological and behavioral patterns and evolution. In the Turkana Depression these findings indicate complex environmental dynamics at local and regional scales between the Lower Omo Valley, West Turkana and East Turkana [1,2]. The former may have provided an ecological refugium for many species, including hominins, but the environmental differential remains to be further characterized.

This project uses suids (pigs) as a model to further investigate the ecological differential across time and space within Turkana. Because suids share significant ecological and evolutionary parallels with hominins, they could serve as a comparative model to provide insights into hominin responses to environmental stresses that were common to both taxa [3,4]. Was the Lower Omo Valley a refugium for some suid species? If so, in what ways? What do these results tell us about ecological opportunities for hominins, and the mechanisms underlying their evolutionary history? Using a multiproxy approach combining enamel stable isotopes, dental microwear texture analysis (DMTA) and relative abundances, this research examines spatiotemporal variations in dietary niches and community structures of Turkana Depression suids at local and regional scales, and how these variations relate to evolutionary dynamics.

Here, we provide an integrative study on the dietary ecology of the suid genera *Notochoerus* (DMTA: n=51; isotopes: n=95), *Kolpochoerus* (DMTA: n=83; isotopes: n=129) and *Metridiochoerus* (DMTA: n=24; isotopes: n=118) from the Shungura Formation (Lower Omo Valley, Ethiopia). In light of the results of their dietary preferences, we also discuss variations in suid relative abundances through the Shungura sequence and compare them to those in East and West Turkana, bringing new data that highlight ecological heterogeneity within Turkana.

Dietary proxies indicate that both *Kolpochoerus* [5] and *Notochoerus* were relying on low-abrasive grasses, likely growing under humid conditions. *Notochoerus*, the most abundant genus until ca. 2.9 Ma, then decreased in relative abundance and was later replaced by *Kolpochoerus* but persisted for a slightly longer time in the Omo Valley than in East and West Turkana. Conversely, *Metridiochoerus* most likely relied on abrasive grasses that grew under more arid conditions. It had a narrow dietary niche and was much less abundant in the Omo Valley than in other areas. Altogether, our results are consistent with the hypothesis of the Omo Valley retaining more mesic environmental settings than in East and West Turkana and acting as an ecological refugium for some taxa. Our results raise questions that ongoing data collection and analysis from East and West Turkana will help address, refining paleoecological interpretations at local and regional scales.

We deeply thank all visited institutions and their curatorial staff, particularly the Ethiopian Heritage Authority (EHA)/National Museum of Ethiopia (T. Getachew, S. Selassie, M. Bitew) for authorizing our field research and for granting us permission to sample suid dental remains from the Omo collections, the National Museums of Kenya and the Turkana Basin Institute. We are deeply indebted to the hundreds of people who participated to the fieldwork missions of the IORE, of the OGRE and of other research programs, who managed collections and databases, who prepared specimens, who contributed to their study, who provided financial support, who helped with administrative processes, and who provided advice and moral support. The OGRE is extremely grateful to the EHA, the SNNPR, the South Omo Zone, the Nyangatom and Dassanetch Weredas and their people for their help and reception. The research was conducted in the framework of the Junior Fellowship funded by the American School of Prehistoric Research (Harvard University), and of the Omo Group Research Expedition (OGRE) principally funded by the Ministry of Europe and Foreign Affairs, the French National Research Agency, the Nouvelle-Aquitaine region, CNRS INEE, PALEVOPRIM (University of Poitiers), and the Fyssen Foundation.

References: [1] Bobe, R., 2011. Fossil mammals and paleoenvironments in the Omo-Turkana Basin. *Evolutionary Anthropology: Issues, News, and Reviews*. 20, 254–263. [2] Levin, N.E., Brown, F.H., Behrensmeyer, A.K., Bobe, R., Cerling, T.E., 2011. Paleosol carbonates from the Omo Group: Isotopic records of local and regional environmental change in East Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 307, 75–89. [3] Hatley, T., Kappelman, J., 1980. Bears, pigs, and Plio-Pleistocene hominids: A case for the exploitation of belowground food resources. *Human Ecology*. 8, 371–387. [4] Bishop, L.C., 1999. Suid Paleoecology and Habitat Preferences at African Pliocene and Pleistocene Hominid Localities. In: Bromage, T.G., Schrenk, F. (Eds.), *African Biogeography, Climate Change, & Human Evolution*. Oxford University Press, p. 216–225. [5] Louail, M., Souron, A., Merceron, G., Boisserie, J.-R., 2025. New insights on feeding habits of *Kolpochoerus* van Hoepen & van Hoepen, 1932 from the Shungura Formation (Lower Omo Valley, Ethiopia) using dental microwear texture analysis. *Comptes Rendus Palevol*. 24.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Reconstructing loading from the internal bone structure of the *Homo naledi* foot

Andrea Lukova<sup>1,2</sup>, Sebastian Bachmann<sup>3</sup>, Alexander Synek<sup>3</sup>, Dieter H. Pahr<sup>3</sup>, Tracy L. Kivell<sup>1,4</sup>, Lee R. Berger<sup>4,5,6</sup>, Bernhard Zipfel<sup>7</sup>, Zewdi J. Tsegai<sup>8</sup>, Matthew M. Skinner<sup>1,4</sup>

1 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 2 - Department of Anthropology, University of West Bohemia in Pilsen, Pilsen, Czech Republic · 3 - Institute of Lightweight Design and Structural Biomechanics, TU Wien, Wien, Austria · 4 - Centre for the Exploration of the Deep Human Journey, University of the Witwatersrand, Johannesburg, South Africa · 5 - The National Geographic Society, 1145 17<sup>th</sup> St NW, Washington DC 20036, USA · 6 - The Carnegie Institution for Science, 5251 Broad Branch Rd NW, Washington, DC 20015, USA · 7 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa · 8 - Department of Organismal Biology and Anatomy, The University of Chicago, Chicago, Illinois, USA

*Homo naledi* is a key taxon for understanding locomotor variation among fossil hominins due to its unique paleoanthropological context and unusual mosaic of postcranial features [1]. While previous studies have primarily focused on external morphology, often describing the foot as relatively derived [2], analyses of internal structural properties remain limited, despite their critical importance for inferring habitual loading regimes and joint function in fossils [3]. Trabecular bone architecture provides a powerful window into biomechanical environments, with spatial distributions of bone volume fraction (BV/TV) capturing variation in local loading intensity and structural inhomogeneity, while the degree of anisotropy (DA) reflects the extent of trabecular alignment and potential specialization for directional loading [4]. The talus and first metatarsal (Mt1) are particularly informative in distinguishing arboreal from terrestrial locomotor strategies due to their central roles in weight transfer and foot stabilization [5].

This study examines whether *H. naledi* exhibits a trabecular pattern distinct from extant hominids, and whether spatial variation in BV/TV and DA in the talus and Mt1 can inform reconstructions of joint stability and loading direction. High-resolution microCT scans of the talus (U.W. 101-148/149) and Mt1 (U.W. 101-1443) in *H. naledi* and a comparative sample of human (talus/Mt1: n=19/18) and non-human apes (talus/Mt1: *Gorilla* sp., n=16/7; *Pan troglodytes*, n=22/8; *Pan paniscus*, n=8/12; *Pongo* sp., n=9/10) were analyzed. Trabecular distributions were quantified using a canonical holistic morphometric analysis (cHMA), which combines holistic morphometric methods with a statistical free-form deformation model, following established protocols [6].

Our results suggest that despite its relatively human-like external morphology, the *H. naledi* talus exhibits an intermediate trabecular pattern. The region of high BV/TV and DA at the talonavicular joint extends medio-laterally across the head of the talus, suggesting a mobile midfoot, while the trochlea displays a more complex pattern with regions suggestive of various loading regimes: dorsiflexion-dominant loading (as in non-human apes), more neutral loading (as in humans), and inversion/eversion loading (as in orangutans). In the Mt1, trabecular organization is overall more human-like in *H. naledi*, particularly at the base, which exhibits plantar-medial loading. However, the dorsal aspect of the head, crucial in human bipedal push-off, is absent, complicating interpretations. Interestingly, the plantar head is most similar to orangutans, while lateral base loading appears reduced to only the dorsal part of the proximal articular surface, aligning with human-like midfoot stabilization. Despite its human-like external form, *H. naledi* shows intermediate trabecular patterns, with human-like loading at the ankle and first metatarsal base, but a more mobile midfoot reflected in the talonavicular joint. These findings highlight the mosaic and potentially unique nature of the internal foot structure in *H. naledi*, reinforcing its significance in discussions of locomotor diversity and functional adaptation in early hominins.

For access to specimens, we thank the following individuals/institutions: Max Planck Institute for Evolutionary Anthropology (P. Gunz); Museum für Naturkunde - Leibniz Institute for Evolution and Biodiversity Science (F. Mayer, C. Funk); Powell-Cotton Museum (I. Livne); Royal Museum for Central Africa (E. Gilissen); Johann-Friedrich-Blumenback-Institute for Zoology and Anthropology, Georg-August University, Göttingen (B. Grosskopf); University of the Witwatersrand. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No. 819960).

References: [1] Berger, L. R., Hawks, J., de Ruiter, D. J., Churchill, S. E., Schmid, P., Deleuzene, L. K., ... & Zipfel, B. (2015). *Homo naledi*, a new species of the genus *Homo* from the Dinaledi Chamber, South Africa. *Elife*, 4, e09560. [2] Harcourt-Smith, W. E., Throckmorton, Z., Congdon, K. A., Zipfel, B., Deane, A. S., Drapeau, M. S., ... & DeSilva, J. M. (2015). The foot of *Homo naledi*. *Nature Communications*, 6(1), 8432. [3] Kivell, T. L. (2016). A review of trabecular bone functional adaptation: what have we learned from trabecular analyses in extant hominoids and what can we apply to fossils? *Journal of Anatomy*, 228(4), 569-594. [4] Maquer, G., Musy, S. N., Wandel, J., Gross, T., & Zysset, P. K. (2015). Bone volume fraction and fabric anisotropy are better determinants of trabecular bone stiffness than other morphological variables. *Journal of Bone and Mineral Research*, 30(6), 1000-1008. [5] Conroy, G. C., & Rose, M. D. (1983). The evolution of the primate foot from the earliest primates to the Miocene hominoids. *Foot & Ankle*, 3(6), 342-364.

Poster Presentation Number 94, Session 2, Friday 14:00 - 15:30

## Tracing the evolutionary path: comparing cerebellar and brain stem position and the posterior cranial fossa in humans, chimpanzees, and *Australopithecus* through tentorium cerebelli attachments

Xichen Luo<sup>1</sup>, Sandra Martelli<sup>2</sup>

1 - Division of Biosciences, Faculty of Life Sciences, London, UK · 2 - UCL Centre for Integrative Anatomy (CIA), Research Department of Cell and Developmental Biology, Faculty of Life Sciences, London, UK

Modern humans have a distinct globular brain case, setting them apart from all their relatives. Morphology of the parietal and occipital bones is crucial for vault shape, but cerebellum position relative to cerebrum could be significant regarding the posterior cranial base configuration. Evolutionary developmental studies highlight cranial shape differences e.g. between modern humans and Neanderthals [1], which might align with the modern human-specific development of tentorium cerebelli (TC) [2] but little is known about developmental pathways shared with apes. Varying head carriage demands may also drive these adaptations, influencing the posterior cranial base configuration and subsequently, the varying position of the hominoid larynx.

We explore the variation in the bony attachments of the tentorium cerebelli in modern humans and chimpanzees, in relation to stable and variable neurovascular outlets of the cranial base [3] and we aim to understand how the posterior cranial fossa accommodates changes in cerebellum/brain stem vs. cerebrum size during evolution. We will test adult configurations on a fossil hominin, *Australopithecus africanus*, to see how it contributes as a driver of shifts in posterior cranial fossa size. We also try to determine if cranial fossa size variation, restricted by TC placement, could lead to reconfigurations of the hyoid attachments.

Using Geometric-morphometrics, Principal Components Analysis, ANOVA, and Discriminant Analysis/permutation tests, we defined TC bony attachments by 11 landmarks on the sphenoid, temporal, parietal, and occipital endo-surfaces and also collected 52 landmarks defining the stable neurovascular outlets optic foramen (OF), internal acoustic meatus (IAM), stylomastoid foramen (SF), jugular foramen (JF), hypoglossal canal (HC), and the variable ones carotid canal (CC) and foramen magnum (FM) of 23 adult humans, 24 adult chimpanzees, and the *A. africanus* specimen Sts5.

PCs 1 and 2 account for 60.8% of total shape variation: PC1 (53.9%) accounts for taxon differences, PC2 (6.9%) for intra-species variation. ANOVA, Discriminant functions and Permutation tests separated all taxa at  $p > 0.05$  level but showed high overlap for pairings of humans with *A. africanus* and chimpanzees with *A. africanus*. The TC's lateral attachments maintained the same configuration in relation to OF, IAM, SF, JF, and HC in all species. The anterior attachments on the posterior clinoid process of the sphenoid are relatively stable in relation to the IAM. However, the posterior attachments of the TC on the occipital bone differ in antero-posterior distance to the stable landmarks, being placed at relative larger antero-posterior and infero-superior distance in humans compared to the other two species, but *A. africanus* shows a slightly closer affinity here with the human configuration than the chimpanzee one. The variable FM and CC vary in similar ways in chimpanzee and *A. africanus* vs. humans.

The stable position of the anterior attachments of the TC the sphenoid and the lateral ones on the temporal, parietal, and occipital bones in relation to stable neurovascular outlets likely reflect its early establishment in embryonic history, shared between humans, chimpanzees, and *Australopithecus*. Phylogenetic and species-specific adjustments for cerebellar to cerebral proportions occur later in prenatal development [4,5], which can lead to restrictions in areas for cerebellum expansion in later developmental stages. This may affect the position/size of the petrous part of the temporal bone and the foramen magnum, potentially rearranging the muscular hyoid attachments and influencing vocal tract configuration. *Australopithecus* shows a slightly more expanded posterior cranial fossa compared to chimpanzees and a rearranged position of the foramen magnum in relation to TC and IAM. Further studies on postnatal development in modern and fossil taxa are needed.

We thank C.E.P. Zollikofer and M. Ponce de Leon, Universität Zürich, F. Spoor, Natural History Museum London, Takeshi Nishimura and the Digital Morphology Museum at the Primate Research Institute, Kyoto University, MorphoSource and J. Hodler and his team at orthopaedic University hospital Zurich for access to comparative chimpanzee material and, CT scan access. We are also very grateful to Frédéric Richard, Aix-Marseille Université and S. Blau and VIFM, Monash University Melbourne for providing the human CT scan data set.

References: [1] Gunz, P., Neubauer, S., Maureille, B., Hublin, J.-J., 2010. Brain development after birth differs between Neanderthals and modern humans. *Current Biology*. 20, R921–R922. [2] Jeffery, N., 2002. Differential regional brain growth and rotation of the prenatal human tentorium cerebelli. *Journal of Anatomy*. 200, 135–144. [3] Martelli, S.A., Dean, M.C., 2015. Stability of neurovascular vs. musculoskeletal landmarks on human and chimpanzee (*Pan troglodytes*) cadavers - implications for interpreting fossil hominins. *Proceedings of the European Society for the Study of Human Evolution*. 4, 151. [4] Gunz, P., Neubauer, S., Golovanova, L., Doronichev, V., Maureille, B., Hublin, J.-J., 2012. A uniquely modern human pattern of endocranial development. *Insights from a new cranial reconstruction of the Neandertal newborn from Mezmaiskaya*. *Journal of Human Evolution*. 62, 300–313. [5] Matsunari, C., Kanahashi, T., Otani, H., Imai, H., Yamada, S., Okada, T., Takakuwa, T., 2022. Tentorium cerebelli formation during human embryonic and early fetal development. *The Anatomical Record* 306: 515–526.

Poster Presentation Number 95, Session 2, Friday 14:00 - 15:30

## The projectile weapons of the Uluzzian of Klissoura Cave 1, Greece: an integrated study of technology, usewear and 3D approaches of the Lunates

Giulia Marciani<sup>1,2</sup>, Simona Arrighi<sup>2</sup>, Serena Lombardo<sup>3</sup>, Carolin Röding<sup>3</sup>, Nicholas Thompson<sup>3</sup>, Effrosyni Roditi<sup>3</sup>, Vangelis Tourloukis<sup>3,4</sup>, Stefano Benazzi<sup>1</sup>, Katerina Harvati<sup>3</sup>

1 - University of Bologna, Dipartimento di Beni Culturali, Ravenna, Italy · 2 - University of Siena, Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente, U. R. Preistoria e Antropologia, Siena, Italy · 3 - Palaeoanthropology, Institute for Archaeological Sciences and Senckenberg Centre for Human Evolution and Palaeoenvironment, Department of Geosciences, Eberhard Karls University of Tübingen, Tübingen, Germany · 4 - University of Ioannina, School of Philosophy, Department of History and Archaeology, Ioannina, Greece

The Uluzzian, dated between ca. 43,000 and 40,000 BP, represents one of the earliest *Homo sapiens* dispersals into Europe, documented in both Italy and Greece. It is characterised by cohesive technological and subsistence behaviours, the use of colourants, and the systematic production of bone tools and ornaments [1]. A hallmark of the Uluzzian is the lunate—a backed tool with a crescent-retouched edge opposite a rectilinear cutting edge. At Grotta del Cavallo, lunates have been identified as components of projectile weaponry, suggesting that *Homo sapiens* dispersals were accompanied by the use of projectile technology [2]. This study offers the first integrated technological, functional, and morphometric analysis of lunates from Klissoura Cave 1, the most important Uluzzian site outside Italy [3]. It investigates their production and confirms their use as projectiles in mechanically delivered weapons.

The analysed sample consists of 74 lunates. The integrated protocol combines technological analysis—to evaluate flaking methods, support selection, and retouching techniques—with use-wear analysis, applying both low- and high-power approaches to identify diagnostic impact traces. The latter focused on fracture types indicative of impact, describing their morphological, dimensional, and positional attributes. In addition, 2D and 3D geometric morphometric analyses were conducted to quantify shape variation and assess correlations with technological features, raw material, and use-wear. Accordingly, two fixed and a total of 18 semi-landmarks along three curves, capturing both the 2D outline and thickness, were digitised on surface models of each lunate. The resulting landmark dataset was analysed using the toolkit of geometric morphometrics [4].

The blanks for lunates are bladelets or elongated blanks, often featuring a natural back or exploiting natural affordances to create a backed edge. They were typically produced from unidirectional frontal platform cores or semi-circumferential systems, using both direct and bipolar percussion. Lunates were classified into four categories based on their production phase, degree of completeness [5], and the invasiveness of the retouch. Unfinished Lunates (4) are defined as blanks partially worked; Finished Lunates (57) are characterised by a fully or partially retouched back, exhibiting either invasive or marginal retouch; Re-shaped Lunates (4) are specimens showing clear evidence of re-shaping along the back following use-related fractures or knapping errors. Finally, Broken Lunates (9) include specimens that were fractured either during manufacture or after use.

The identification of these lunates as projectile elements is based on converging lines of evidence. Detailed analysis of all 74 specimens revealed impact-related damage on 30 pieces on the category of finished and broken lunates: 12 with clear diagnostic fractures consistent with projectile use, and 18 with less conclusive but possible impact marks. The remaining 44 exhibited either ambiguous traces or no use-wear. 2D and 3D geometric morphometric analyses indicate that lunates made of flint are less variable in shape than those made of radiolarite. While both raw material groups include pieces with and without use-wear, lunates showing use-wear tend to be relatively elongated, with a straight to slightly concave unretouched edge and a distinct crescent shape on the opposing side. Given the presence of all four types—unfinished, finished, re-shaped and broken—and the patterned occurrence of use-wear on specific categories of specimens, we interpret the Klissoura lunate assemblage as the result of on-site production and maintenance activities.

The integration of technological analysis, use-wear, and morphometrics allows for robust cross-validation of results, strengthening the interpretation of lunates as projectile implements and demonstrating the value of combining independent datasets to reconstruct past human behaviour.

This research is funded by the European Research Council (ERC-AdG-101019659 “FIRSTSTEPS” awarded to K. Harvati).

References: [1] Marciani, G., Carmignani, L., Djakovic, I., Roussel, M., Arrighi, S., Rossini, M., Bosch, F., Ronchitelli, A., Benazzi, S., Moroni, A., Soressi, M., 2025. The Uluzzian and Châtelperronian: No technological affinity in a shared chronological framework. *Journal of Paleolithic Archaeology*. 8. [2] Sano, K., Arrighi, S., Stani, C., Aureli, D., Bosch, F., Fiore, I., Spagnolo, V., Ricci, S., Crezzini, J., Boscato, P., Gala, M., Tagliacozzo, A., Birarda, G., Vaccari, L., Ronchitelli, A., Moroni, A., Benazzi, S., 2019. The earliest evidence for mechanically delivered projectile weapons in Europe. *Nature Ecology & Evolution*. 3, 1409–1414. [3] Kaczanowska, M., Kozłowski, J., Sobczyk, K., 2010. Upper Palaeolithic human occupations and material culture at Klissoura Cave 1. *Eurasian Prehistory*. 7, 133–285. [4] Slice, D.E., 2007. Geometric Morphometrics. *Annual Review of Anthropology*. 36, 261–281. [5] Moroni, A., Ronchitelli, A., Arrighi, S., Aureli, D., Bailey, S.E., Boscato, P., Bosch, F., Capecechi, G., Crezzini, J., Douka, K., Marciani, G., Panetta, D., Ranaldo, F., Ricci, S., Scaramucci, S., Spagnolo, V., Benazzi, S., Gambassini, P., 2018. Grotta del Cavallo (Apulia–Southern Italy). The Uluzzian in the mirror. *Journal of Anthropological Sciences*, 96, 125–160.

Poster Presentation Number 96, Session 2, Friday 14:00 - 15:30

## Osteogenic tumor in early *Homo* from Dmanisi

Ann Margvelashvili<sup>1,2,3</sup>, David Lordkipanidze<sup>1,3</sup>

1 - Georgian National Museum, Tbilisi, Georgia · 2 - The University of Georgia, Tbilisi, Georgia · 3 - Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia

The Dmanisi Plio-Pleistocene site, located in Dmanisi, Georgia, 80 km southeast of Tbilisi, is a remarkable paleolithic site dating back 1.81-1.76 million years ago. Stratified between basaltic lava flows and Bronze Age and Medieval archaeological layers, the site has yielded five nearly perfectly preserved hominin crania and four associated mandibles, all discovered within the same geological layer dated to 1.77ma. These fossils represent a unique opportunity to study the morphological variation of a single paleodeme and to investigate aspects of health, diet, behavior, and social structure [1,2]. The individuals range in age from juvenile and subadult to mature adults and edentulous old adult. Here, we present the clinical case of D3444 cranium - an edentulous individual discovered during the 2002 excavations.

D3444 cranium was examined macroscopically, both externally and internally. 3D data for external and internal structure analyses were acquired with multislice helical CT in coronal orientation with 0.5mm collimation. Cross-sectional images were reconstructed at 0.2 mm isotropic voxel volumes. The data analysis was performed using software OsiriX MD v. 12.2.0 and Avizo Lite v. 2020. For differential diagnosis, primarily taphonomical processes were excluded and then both paleopathological and modern clinical criteria were applied.

D3444 exhibits a rare identified case of osteogenic tumor in early *Homo*. The irregular oval-shaped neoplasm originates from the antero-superior surface of the left supraorbital torus of the frontal bone, near the glabellar region and extends toward the supraorbital notch, not reaching it. It spans anteriorly and posteriorly across the rim, measuring 1.65 cm in maximum length, 1.08 cm in width, and 4.22 mm in thickness. The mass appears compact in structure, with smooth margins. A gap is observed between the neoplasm and the healthy bone at the base of the formation, while contact is preserved along the edges—particularly in the medial region. The areas of contact exhibit a compact bone structure. Based on these criteria and considering its cranial location, the most plausible diagnosis is an osteoma—a benign tumor characterised by defined margins, dense bone tissue in cross-section, a rounded mound-like shape, with a typical occurrence on cranial bones [3].

Tumors have a multifactorial etiology, involving genetic, environmental, and lifestyle factors. The disease itself has existed among vertebrates for at least 350 million years. However, tumors in early human fossils are extremely rare, with only a few cases reported to date [4,5]. This rarity can be attributed to: (1) challenges in disease identification; (2) difficulties in differential diagnosis; (3) the scarcity of fossil specimens; (4) the low likelihood of tumors affecting bone; and (5) the low probability of discovering fossilised tumorous bones.

Given its rarity in fossil record, the Dmanisi case represents a significant contribution to paleopathological research and may highlight the need to re-examine other fossil specimen to ensure that no pathological conditions have been overlooked.

We are grateful for the assistance provided by Sopho Kiladze, Grigol Nemsadze, and the Dmanisi Team. A.M. was supported by the Shota Rustaveli National Science Foundation of Georgia (SRNSFG) - YS-21-1595; Laboratory equipment of the Georgian National Museum was provided by Alexander von Humboldt Foundation.

References: [1] Margvelashvili, A., Zollikofer, C.P.E., Lordkipanidze, D., Tafforeau, P., Ponce de León, M.S., 2016. Comparative analysis of dentognathic pathologies in the Dmanisi mandibles. *American Journal of Physical Anthropology*. 160, 229–253. [2] Margvelashvili, A., Tappen, M., Rightmire, G.P., Tsikaridze, N., Lordkipanidze, D., 2022. An ancient cranium from Dmanisi: Evidence for interpersonal violence, disease, and possible predation by carnivores on Early Pleistocene *Homo*. *Journal of Human Evolution*. 166, 103180. [3] Grauer, A.L. (Ed.), 2011. *A Companion to Paleopathology*. Blackwell Publishing Ltd. [4] Odes, E.J., Delezenne, L.K., Randolph-Quinney, P.S., Smilg, J.S., Augustine, T.N., Jakata, K., Berger, L.R., 2018. A case of benign osteogenic tumour in *Homo naledi*: Evidence for peripheral osteoma in the U.W. 101-1142 mandible. *International Journal of Paleopathology*. 21, 47–55. [5] Randolph-Quinney, P.S., Williams, S.A., Steyn, M., Meyer, M.R., Smilg, J.S., Churchill, S.E., Odes, E.J., Augustine, T., Tafforeau, P., Berger, L.R., 2016. Osteogenic tumour in *Australopithecus sediba*: Earliest hominin evidence for neoplastic disease. *South African Journal of Science*. 112, 7.

Poster Presentation Number 97, Session 2, Friday 14:00 - 15:30

## Assessing the paleoenvironmental conditions that late Neanderthal and anatomically modern humans faced in Grotta Fumane

Ana B. Marín-Arroyo<sup>1</sup>, Carmen Rodríguez Rumayor<sup>1</sup>, Marco Vidal-Cordasco<sup>1</sup>, Marco Peresani<sup>2,3</sup>

1 - Grupo I+D+i EvoAdapta (Evolución Humana y Adaptaciones durante la Prehistoria), Dpto. Ciencias Históricas, Universidad de Cantabria, Santander, Spain · 2 - Department of Humanistic Studies, Anthropology and Prehistory, Section of Paleobiology, Ferrara, Italy · 3 - Institute of Environmental Geology and Geoengineering, National Research Council, Milano, Italy

Grotta Fumane, located in northern Italy, is a relevant site for studying the transition from the Middle to the Upper Palaeolithic and the replacement of Neanderthals by anatomically modern humans (AMH) during Marine Isotope Stage 3 (MIS 3), a period characterised by rapid and abrupt climatic changes. This site is notable for documenting the early presence of *Homo sapiens* in Europe, as it contains a well-defined stratigraphic sequence.

To reconstruct the environmental conditions they lived in and exploited and in order to assess how those conditions may have affected the subsistence strategies of both human species, stable isotope analysis (carbon, nitrogen, sulfur) was carried out on bone collagen from macromammal remains with evidence of human manipulation, recovered from ten archaeological levels (A9 to D3) spanning the Late Mousterian (Neanderthals) and the Aurignacian (early modern humans). The results of this isotopic study revealed a shift in the local ecology over time. The increase in  $\delta^{13}\text{C}$  values in herbivores, with little variation in  $\delta^{15}\text{N}$ , suggests a transition from humid landscapes with greater tree cover to more open ones in a drier climate. This environmental change was correlated with a shift in hunting strategies: during the Late Mousterian, exploitation focused on red deer and roe deer, which typically graze in forested areas. In contrast, throughout the Aurignacian, the faunal assemblage suggests the presence of these early modern humans in a cold environment with predominantly open landscapes and patchy forests, mainly exploited by Alpine ibex (*Capra ibex*) and chamois (*Rupicapra rupicapra*), associated with shrubby landscapes. The low  $\delta^{15}\text{N}$  values in caprids are consistent with a diet in high-mountain landscapes. The  $\delta^{34}\text{S}$  values indicate a local origin of the herbivores, omnivores and carnivores, suggesting that both Neanderthals and AMH exploited the mountainous areas and plains near the site. In summary, this study shows the different ecological niches exploited by both human species in Fumane during the late MIS 3.

The Net Primary Productivity (NPP) estimate at Fumane highlights how environmental fluctuations affected local biotic resources. Cold climatic conditions, especially during the Heinrich 4 event, reduced NPP, limiting resource availability and decreasing species diversity and abundance. Northern Italian sites such as Fumane, Riparo Bombrini, and Riparo Mochi provide evidence that modern humans adapted to these harsh environments, with open ecosystems and fragmented forests. From a broader perspective, comparing spatiotemporal NPP fluctuations with AMH subsistence strategies supports the rapid dispersal and resilience of *Homo sapiens* in a mosaic of environments affected by significant climate change. Taken together, the research at Grotta Fumane, through isotopic and archaeozoological data, provides a detailed picture of the subsistence adaptations of Neanderthals and early modern humans to the changing landscapes and climates of the late MIS 3, showing both the exploitation of local resources and the focus on different prey types as the environment evolved.

The European Research Council funded this research under the European Union's Horizon 2020 Research and Innovation Programme (grant agreement number 818299; SUBSILIENCE project; <https://www.subsilience.eu>). We acknowledge L. Agudo Pérez, G. Terlato for selection in Ferrara University and for technical pretreatment of bone collagen extraction in EvoAdapta with M. Fernández-García.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## **Dispersed female networks: female gorillas' inter-group relationships influence dispersal decisions**

**Victoire Martignac<sup>1</sup>, Winnie Eckardt<sup>2</sup>, Samedi Mucyo<sup>2</sup>, Tara Stoinski<sup>2</sup>, Veronica Vecellio<sup>2</sup>, Robin Morrison<sup>1,2</sup>**

1 - Department of Evolutionary Anthropology, University of Zürich · 2 - Dian Fossey Gorilla Fund

Dispersal between social groups is a fundamental aspect of many animal societies, impacting the transmission of genes, knowledge, and culture, but also individual fitness. However, our understanding of dispersal remains limited, and little is known about the information individuals use when dispersing between groups. Mountain gorillas have large-scale societies, in which individuals' social relationships extend beyond their current social group. They exhibit a flexible dispersal pattern, with approximately 50% of females and males dispersing from their natal groups, and females often dispersing multiple times across their lives. Using two decades of data from the Dian Fossey Gorilla Fund (2003-2023) including 154 dispersal events from 61 females across 15 social groups, we examined how social familiarity influenced females' dispersal. We modelled dispersing females's familiarity with nearby groups based on annual home-range overlap, intergroup encounters, and past co-residency with group members in their natal group or another previous group. Females avoided groups that contained males from their natal group, but preferred groups containing females they had previously resided with. Our findings suggest that females prioritize inbreeding avoidance and the maintenance of female relationships in their dispersal decisions. Joining a new group can be costly, with immigrant females often facing high rates of aggression and stress. Pre-existing relationships may therefore reduce these dispersal costs. In addition to highlighting the importance of female relationships in a species where these are generally assumed to be weak, our study lends insights into the influence of mountain gorillas' large-scale society on individuals' dispersal decisions. This not only contributes to a better understanding of population dynamics in this endangered ape, but also of the foundation of our own flexible society, characterised by individuals moving between social groups throughout their lifetimes.

We thank the Rwanda Development Board (RDB) for their long-term support of the Dian Fossey Gorilla Fund and the many Fossey Fund field staff for their years of work monitoring the gorilla groups and collecting data. We are grateful to members of the University of Zurich's Human Evolutionary Ecology group for their constructive feedback throughout the project.

Podium Presentation, Session 00, day 00:00-00:00

## Detecting microevolutionary trends in fossil hominin populations

Jesse M Martin<sup>1</sup>, Marta Mirazon Lahr<sup>1</sup>

<sup>1</sup> - Leverhulme Centre for Human Evolutionary Studies, Department of Archaeology, University of Cambridge, Cambridge, United Kingdom

Microevolutionary changes operating at the population level are the engine room that drives taxic diversity; however, these processes have been largely invisible to palaeoanthropology because of small sample sizes and imprecise dating. The genus *Paranthropus* includes at least three species from southern and eastern Africa, characterised by small brains and hypertrophic masticatory systems. *Paranthropus robustus* from southern Africa is perhaps one of the best sampled Pleistocene hominin species. Known from at least five separate sites within the Cradle of Humankind (Kromdraai, Swartkrans, Gondolin, Coopers D, Drimolen), its sample size is large, particularly from three of these sites (Kromdraai, Swartkrans, Drimolen). With the discovery of each new site and the fossils preserved therein, the observed range of morphological variation within *P. robustus* has increased. Significantly, the addition of the purportedly female DNH 7 cranium from Drimolen extended the species range of variation beyond that of *G. gorilla* [1]. This observation has in turn informed secondary hypotheses concerning the paleobiology of *Paranthropus robustus*, placing them closer to *G. gorilla* than *H. sapiens* in terms of life history parameters and group dynamics. Similar degrees of morphological variability observed within *P. boisei* from eastern Africa have also traditionally been attributed to sexual dimorphism, suggesting a *G. Gorilla* like range of variation may be a genus level adaptation. However, recent work to chronologically date the site of Drimolen has demonstrated that, while occupying a constrained geographic area, the *P. robustus* bearing Drimolen Main Quarry (DMQ), Swartkrans Member 1 Hanging Remnant (SM1HR) and Kromdraai B (KB) deposits plausibly sample different time periods, with DMQ likely ~200 Ka older than KB and SM1HR [2]. The 2018 discovery of the male DNH 155 *P. robustus* cranium from DMQ demonstrates that both male and female DMQ specimens share a unique suite of primitive and derived characters distinct from *P. robustus* at KB and SM1HR. Sexual dimorphism thus cannot explain these differences, and because DMQ is likely older than KB and SM1HR, microevolutionary change within the *P. robustus* lineage is a plausible hypothesis [3]. With the addition of new fossils, preliminary investigations of the eastern African *P. boisei* sample also suggest that sexual dimorphism may have been overestimated, and at least some of the observed variation within *P. boisei* crania may be explained by geographically and / or chronologically distinct populations. Minimally, we contend that explaining high degrees of morphological variation within species as either the result of extreme sexual dimorphism or the amalgam of chronologically and morphologically distinct populations are meaningful biological alternatives worthy of further investigation. This talk will explore how identifying microevolutionary changes within single evolving lineages can inform secondary hypothesis concerning hominin life histories, group dynamics, evolutionary trajectories, and behaviour.

This work acknowledges funding from Australian Research Council Discovery Grant no. DP170100056 and the Ng'ipalajem Project (ERC Advanced Grant #101020478).

References: [1] Lockwood, C.A., Menter, C.G., Moggi-Cecchi, J., Keyser, A.W., 2007. Extended Male Growth in a Fossil Hominin Species. *Science*. 318, 1443–1446. [2] Herries, A.I.R., Martin, J.M., Leece, A.B., Adams, J.W., Boschian, G., Joannes-Boyau, R., Edwards, T.R., Mallett, T., Massey, J., Murszewski, A., Neubauer, S., Pickering, R., Strait, D.S., Armstrong, B.J., Baker, S., Caruana, M.V., Denham, T., Hellstrom, J., Moggi-Cecchi, J., Mokobane, S., Penzo-Kajewski, P., Rovinsky, D.S., Schwartz, G.T., Stammers, R.C., Wilson, C., Woodhead, J., Menter, C., 2020. Contemporaneity of *Australopithecus*, *Paranthropus*, and early *Homo erectus* in South Africa. *Science*. 368. [3] Martin, J.M., Leece, A.B., Neubauer, S., Baker, S.E., Mongle, C.S., Boschian, G., Schwartz, G.T., Smith, A.L., Ledogar, J.A., Strait, D.S., Herries, A.I.R., 2020. Drimolen cranium DNH 155 documents microevolution in an early hominin species. *Nature Ecology & Evolution*. 5, 38–45.

Podium Presentation Number 3, Session 0, day 00:00

## Bony labyrinth morphology reveals 40,000 years of settlement history and population isolation in Northeastern Africa

Nicolas Martin<sup>1</sup>, Petr Velemínský<sup>2</sup>, Alessandro Urciuoli<sup>3,4,5</sup>, Lenka Varadzinová<sup>6</sup>, Matthieu Honegger<sup>7</sup>, Stanley H. Ambrose<sup>8</sup>, Daniel Antoine<sup>9</sup>, Steve Brandt<sup>10</sup>, Jessie Cauliez<sup>11</sup>, Henri Duda<sup>1</sup>, Frederick Grine<sup>12,13</sup>, Petra Brukner Havelková<sup>2,6</sup>, Joel D. Irish<sup>14</sup>, Friederike Jesse<sup>15</sup>, Laura Maréchal<sup>16</sup>, Bruno Maureille<sup>1</sup>, Isabelle Ribot<sup>17</sup>, Hélène Rougier<sup>18</sup>, Frédéric Santos<sup>1</sup>, Adrien Thibeault<sup>1</sup>, Donatella Usai<sup>19</sup>, Nicolas Vanderesse<sup>1</sup>, Ladislav Varadzin<sup>20</sup>, Rebecca J. Whiting<sup>10</sup>, Isabelle Crevecoeur<sup>1</sup>

1 - PACEA, UMR 5199, University of Bordeaux, CNRS, Ministère de la Culture, Pessac, France · 2 - Department of Anthropology, Natural History Museum, National Museum, Prague, Czech Republic · 3 - Department of Paleontology, University of Zurich, Zürich, Switzerland · 4 - Institut Català de Paleontologia Miquel Crusafont (ICP-CERCA), Universitat Autònoma de Barcelona, Barcelona, Spain · 5 - Departamento de Ciencias de la Vida, Universidad de Alcalá, Cátedra de Otoacústica Evolutiva y Paleoantropología (HM Hospitales-UAH), Madrid, Spain · 6 - Czech Institute of Egyptology, Faculty of Arts, Charles University, Prague, Czech Republic · 7 - Institute of Archaeology, University of Neuchâtel, Hauterive, Switzerland · 8 - Department of Anthropology, University of Illinois, Urbana, IL, USA · 9 - Department of Egypt and Sudan, The British Museum, London, UK · 10 - Anthropology Department, University of Florida, Gainesville, FL, USA · 11 - CNRS, TRACES, UMR 5608, University Toulouse Jean Jaurès, Toulouse, France · 12 - Department of Anthropology, Stony Brook University, Stony Brook, NY, USA · 13 - Department of Anatomical Sciences, Renaissance School of Medicine, Stony Brook University, Stony Brook, NY, USA · 14 - Research Centre in Evolutionary Anthropology and Paleoecology, School of Biological and Environmental Sciences, Liverpool John Moores University, Liverpool, UK · 15 - University Archives, University of Wuppertal, Wuppertal, Germany · 16 - ARCAN, Department of Anthropology, University of Geneva, Geneva, Switzerland · 17 - Department of Anthropology, Laboratoire de Bioarchéologie Humaine, University of Montréal, Montréal, Québec, Canada · 18 - Department of Anthropology, California State University Northridge, Northridge, CA, USA · 19 - Centro Studi Sudanesi e Sub-Sahariani ETS, Treviso, Italy · 20 - Institute of Archaeology, Czech Academy of Sciences, Prague, Czech Republic

Due to the absence of preserved ancient DNA, the late prehistoric population history of Northeastern Africa is only partially documented. However, based on dental data, recent studies [1] have revealed complex settlement processes in parts of the region during the Holocene. This complexity underscores the need for further research involving larger samples of human remains from geographically and chronologically broader contexts.

Here, we present data on the bony labyrinth morphology—a highly reliable proxy for population affinities [2]—of individuals dated from the Late Pleistocene to the Middle Holocene (44,000–3,000 years ago). These originate from the Nile Valley (n=72), the Horn of Africa (n=10), and Central Africa (n=7). We also include some of the oldest known Late Pleistocene African specimens (i.e., Nazlet Khater 2, Ishango 37, and Hofmeyr). Comparative samples include modern-day South Africans (n=30), European Neandertals (n=21) and Upper Paleolithic *Homo sapiens* (n=8). Three analytical methods were used: a 2D measurement-based method [3], a 3D landmark-based method [4], and a surface deformation-based approach [5].

All analyses yielded similar results, revealing significant morphological differences between Late Pleistocene–Early Holocene populations and later food-producing groups from the Nile Valley. This aligns with previous research on dental inner morphology [1] and shows strong affinities between Late Pleistocene–Early Holocene Nile Valley populations and the Nazlet Khater 2, Ishango 37, and Hofmeyr individuals. This suggests that the Nile Valley foraging population has deep roots in the biological history of Africa and might represent an ancient local population that persisted in the region until the Neolithic transition, when significant biological discontinuity occurred.

Moreover, a subset of Holocene individuals (n=13) exhibited unusual inner ear morphology in the form of 1) a markedly shorter posterior semicircular canal (SCC), 2) slightly reduced anterior SCC, and 3) more tightly coiled cochlea. Though obviously not related, this results in these individuals appearing morphologically closer to, or even within the range of Neandertal variation. Further examination of petrosal bone anatomy revealed inner ear-specific pathologies (e.g., enlarged vestibular aqueduct), with no signs of abnormalities elsewhere in the skeleton. The consistency of these unusual inner ear morphologies, their early developmental timing, and association with congenital pathological changes in the temporal bone suggest a genetic origin (i.e., syndrome, hereditary disorder?), which may have even led to sensorineural hearing loss. This condition is mostly found within the Early Holocene Nile Valley population (8 of 13 cases) and is observed at all sites investigated for the period. Previous dental, archaeological, and paleoenvironmental data for the Nile Valley suggest these individuals likely belonged to a homogeneous forager population that was regionally interconnected yet shaped by environmental constraints. The widespread presence of this potential genetic condition may reflect closed social and biological networks, as well as a significant degree of population isolation, probably induced by environmental factors. Interestingly, similar cases have been identified in Middle Holocene Sudan (n=3), hinting at possible local admixture between the incoming

Neolithic population and earlier local foragers. In contrast, cases from the Horn of Africa (n=2) might represent the first indication of similar patterns of population isolation in that region.

These findings shed new light on the biological diversity and connectivity of Early Holocene populations in Northeastern Africa. The strong parallel between inner ear and dental data highlights the value of integrating novel morphological approaches in the absence of ancient DNA, allowing us to trace population history and structure over more than 40,000 years.

The authors thank the National Corporation for Antiquities and Museums (NCAM) of the Sudan, the Ethiopian Heritage Authority and the Djibouti Center for Research and Studies (especially the Institute of Archeological and Historical Research) for their long-term support. We are grateful to M. Maillot, S. Marchi, J. Reinold, M. Besse, J. Desideri, the Duckworth Laboratory, E. l'Abbe, G. Krüger, C. van der Merwe, A. Gómez-Olivencia, A. Balzeau, C. Schwab, B. Vandermeersch, M.D. Garralda, J.-J. Hublin, M. Langlais, W. Banks, A. Manica, D. Bradley, S. Villotte, P. Semal, E. Cornelissen, P. de Maret, R. Asombang, E. Trinkaus, the Mille-Logya Research project members and the Muséum National d'Histoire Naturelle (Paris) for permission and access to the material. For microCT acquisition, we thank R. Lebrun, B. Clark, K. Smithson, H. Temming, J. Becko, A. Mathys and the PLACAMAT platform. Funding: International Research Project (IRP) ABASC funded by the CNRS-INEE; French government - University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past" (project NeoNile); French National Research Agency (ANR-14-CE31, project BIG DRY); Czech Science Foundation (Project No. GAČR 23-06488S); Cooperatio Program provided by Charles University; Ministry of Culture of the Czech Republic (DKRVO 2024-2028/7.Ib, National Museum, 00023272); National Science Centre – Poland (grant UMO-2020/37/B/HS3/00519), Brussels Institute for Research and Innovation (PRFB 2006/CM/IV/52), Bakeng se Afrika program, the French Ministry of Foreign Affairs (PSPCA program) and the French Embassy in Djibouti.

References: [1] Martin, N., Thibault, A., Varadinová, L., Usai, D., Ambrose, S.H., Antoine, D., Brukner Havelková, P., Honegger, M., Irish, J.D., Jesse, F., Maréchal, L., Osypińska, M., Osypiński, P., Santos, F., Vanderesse, N., Varadin, L., Whiting, R.J., Zanolli, C., Velemínský, P., Crevecoeur, I., 2025. Enamel–dentine junction morphology reveals population replacement and mobility in the late prehistoric Middle Nile Valley. *Proceedings of the National Academy of Sciences*. 122. [2] Ponce de León, M.S., Koesbardiati, T., Weissmann, J.D., Milella, M., Reyna-Blanco, C.S., Suwa, G., Kondo, O., Malaspina, A.-S., White, T.D., Zollikofer, C.P.E., 2018. Human bony labyrinth is an indicator of population history and dispersal from Africa. *Proceedings of the National Academy of Sciences*. 115, 4128–4133. [3] Spoor, F., Hublin, J.-J., Braun, M., Zonneveld, F., 2003. The bony labyrinth of Neanderthals. *Journal of Human Evolution*. 44, 141–165. [4] Gunz, P., Ramsier, M., Kuhrig, M., Hublin, J., Spoor, F., 2012. The mammalian bony labyrinth reconsidered, introducing a comprehensive geometric morphometric approach. *Journal of Anatomy*. 220, 529–543. [5] Urciuoli, A., Martínez, I., Quam, R., Arsuaga, J.L., Keeling, B.A., Díez-Valero, J., Conde-Valverde, M., 2025. Semicircular canals shed light on bottleneck events in the evolution of the Neanderthal clade. *Nature Communications*. 16.

Poster Presentation Number 99, Session 2, Friday 14:00 - 15:30

## Molar wear dynamics in African *Papio* sp. and *Theropithecus gelada*: ecological and evolutionary implications

Laura M Martínez<sup>1,2</sup>, Fernando Ramírez-Rozzi<sup>3</sup>, Ferran Estebaranz-Sánchez<sup>1,2</sup>, Alejandro Romero<sup>4</sup>, Albert E. Dyowe-Roig<sup>1</sup>, Luis Hidalgo-Trujillo<sup>1,2</sup>, Sam Canal-Monsó<sup>1</sup>, Selma López-Romagosa<sup>1</sup>, Alejandro Pérez-Pérez<sup>1,2</sup>

1 - Departament de Biologia Evolutiva, Ecologia i CCA, Facultat de Biologia, Universitat de Barcelona, Spain · 2 - Institut d'Arqueologia de la Universitat de Barcelona, Spain · 3 - Centre National de la Recherche Scientifique (CNRS), Paris, France · 4 - Universitat d'Alacant, Spain

Dental wear is a physiological process dependent on age and diet, characterized by the gradual loss of enamel and the subsequent exposure of dentine on the occlusal surfaces of teeth. Enamel loss results from the action of hard microscopic particles of both intrinsic dietary origin - such as silica-based phytoliths - and extrinsic origin, introduced during food processing, such as grit and dust [1]. Dental wear continues throughout life, and beyond a certain point, it may reduce functional efficiency in food processing [2]. This often corresponds to the complete or near-complete loss of enamel on the occlusal surface, potentially affecting feeding efficiency and, consequently, reproductive fitness.

This study aims to quantify and compare patterns of 3D dentine exposure in three Papionini species –*Theropithecus gelada*, *Papio ursinus* and *Papio anubis*– to evaluate species-specific dental wear trajectories and their potential adaptive significance. The sample includes lower molars (M1, M2, and M3) casts replicated from the original specimens curated in different institutions. Negative molds were obtained using Coltène® silicones, and positives cast were obtained with polyurethane resins. All the teeth were scanned using a Shining® white-light scanner, and the occlusal area of dentine exposure (mm) was measured using the scanner's software for the three teeth of the same row. Sex and locality of the specimens were recorded and considered during analysis to account for potential intra- and inter- population variability. Rates of dentine exposure (mm/year) were estimated based of known eruption ages and the predictable sequence of molar eruption for the infant and juvenile periods. Additionally, regression equations were developed by comparing the dentine exposure of individual molars to the cumulative wear across the entire molar row. This allows us to infer wear dynamics within individuals and assess how each molar contributes to overall dental function throughout development [3].

Results indicate different wear trajectories among taxa. In *Papio species*, M1 consistently displays the highest dentine exposure, reflecting early functional loading. In contrast, *T. gelada* shows quickly dentine exposure in the M2, which become the most worn molar early in development. These interspecific dental wear differences may reflect ecological differences in diet abrasiveness or feeding strategies. *Papio* molars are larger in mesiodistal diameter, however, the high-crowned (hypsodont) molars of *T. gelada* may offset accelerated enamel loss due to their highly abrasive graminivorous diet. These findings highlight functional and evolutionary differences in dental wear strategies and tooth shape with implications for dietary ecology and life history evolution in Papionini primates.

This research has received funding from MCIU/AEI/10.13039/501100011033, PID2023-148818NB-I00 to LMM and APP.

References: [1] Lucas, P.W., van Casteren, A., 2014. The wear and tear of teeth. Medical Principles and Practice. 24, 3–13. [2] Ungar, P.S., 2015. Mammalian dental function and wear: A review. Biosurface and Biotribology. 1, 25–41. [3] Yang, S., Martínez, L.M., Romero, A., Carrascal, S., Guo, J., Dyowe, A.E., Zhang, Q., Pérez-Pérez, A., 2024. Rethinking wear rate analysis: a new dentin exposure proxy and its applications to ancient Chinese populations. Journal of Archaeological Method and Theory. 31, 2053–2081.

Poster Presentation Number 100, Session 2, Friday 14:00 - 15:30

## Deciduous molar variation as a window into human evolution: integrating fossil and modern data

Marina Martínez de Pinillos<sup>1,2</sup>, Mario Modesto-Mata<sup>1,3</sup>, Arthur Thiebaut<sup>1</sup>, Leslea J. Hlusko<sup>1</sup>

1 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Burgos, Spain · 2 - Universidad de Burgos, Burgos, Spain · 3 - Universidad Internacional de La Rioja (UNIR), Logroño, Spain

The analysis of deciduous molar measurements across various hominin species provides a fundamental perspective on dental evolution, ontogenetic development, and dietary strategies throughout human evolution [1]. While deciduous teeth are comparatively rare in the hominin fossil record, their importance in early childhood survival and development makes them especially informative for understanding evolutionary change [2]. Deciduous molars, in particular, offer a unique window into the interplay of genetic, environmental, and ontogenetic factors that have shaped our species.

Fossil evidence shows that early hominins—especially *Paranthropus*—possessed large, robust deciduous molars likely adapted to abrasive diets [3]. Over time, these molars diminished, suggesting evolutionary responses to changing ecological and social conditions, as well as to intrinsic factors conditioned by developmental constraints, genetics, and biomechanics [4]. However, the importance of deciduous molars goes beyond their morphology. Researchers have sought to determine whether certain deciduous teeth are more taxonomically informative than others.

To explore this question, we compiled from the literature a comparative sample of 308 deciduous molars representing four genera: *Ardipithecus*, *Australopithecus*, *Paranthropus* and *Homo*. Then, we analyzed modern human samples from the *Ratón Pérez* collection [5]. This unique collection includes more than 5,000 deciduous teeth from children whose age range is approximately 5-13 years. For this study, we used a sample of 390 upper and lower deciduous molars from children of both sexes. A subset of these data is paired, in that the dm1 and dm2 data are from the same individual (n=59), enabling us to run a series of pairwise comparisons and correlation analyses. By focusing on linear dimensions (mesiodistal, buccolingual, crown index, and crown area), we analyzed the morphological variation of maxillary and mandibular deciduous molars.

The results suggested that mandibular second molars may be the least taxonomically diagnostic, while the maxillary first molars may carry greater taxonomic significance. Our findings also emphasize the challenges posed by small fossil sample sizes, which may obscure true patterns of variability. Nonetheless, the comparison between fossil data and a large, well-documented modern sample provides a valuable framework for interpreting evolutionary trends. Notably, variation within the *Ratón Pérez* collection shows that even a sample size equivalent to that of *Neanderthal* fossil material (~40 individuals) can yield reliable estimates of population-level variability.

In sum, the study of deciduous molars, once a marginal topic in paleoanthropology, is emerging as a powerful tool for exploring human evolution. Integrating fossil data with extensive modern collections such as the *Ratón Pérez* sample allows us to refine our understanding of developmental processes, evolutionary divergence, and the taxonomic value of dental traits. These insights, combined with proteomic, isotopic, and genetic studies, among others, will be crucial in future debates to deepen our understanding of how children have adapted over time.

This research was supported with funding from the European Research Council within the European Union's Horizon Europe (ERC-2021-ADG, Tied2Teeth, project number 101054659), Spanish Foundation for Science and Technology (FECYT), Spanish Ministerio de Economía y Competitividad (CGL2015-65387-C3-3-P), Fundación La Caixa, Fundación Caja de Burgos.

References: [1] Smith, T.M., Tafforeau, P., Reid, D.J., Pouech, J., Lazzari, V., Zermeno, J.P., Guatelli-Steinberg, D., Olejniczak, A.J., Hoffman, A., Radović, J., Makaremi, M., Toussaint, M., Stringer, C., Hublin, J.-J., 2010. Dental evidence for ontogenetic differences between modern humans and Neanderthals. *Proceedings of the National Academy of Sciences*. 107, 20923–20928. [2] Bermúdez de Castro, J.M., Martín-Torres, M., Martín-Francés, L., Martínez de Pinillos, M., Modesto-Mata, M., García-Campos, C., Wu, X., Xing, S., Liu, W., 2017. Early Pleistocene hominin deciduous teeth from the *Homo antecessor* Gran Dolina-TD6 bearing level (Sierra de Atapuerca, Spain). *American Journal of Physical Anthropology*. 163, 602–615. [3] Rabenold, D., Pearson, O.M., 2011. Abrasive, Silica Phytoliths and the Evolution of Thick Molar Enamel in Primates, with Implications for the Diet of *Paranthropus boisei*. *PLoS ONE*. 6, e28379. [4] Ungar, P.S., Hlusko, L.J., 2016. The evolutionary path of least resistance. *Science*. 353, 29–30. [5] Martínez de Pinillos, M., Pantoja-Pérez, A., Fernández-Colón, P., Martín-Francés, L., García-Campos, C., Modesto-Mata, M., Moreno-Torres, C., Bermúdez de Castro, J.M., Martín-Torres, M., 2021. The *Ratón Pérez* collection: Modern deciduous human teeth at the Centro Nacional de Investigación sobre la Evolución Humana (Burgos, Spain). *American Journal of Physical Anthropology*. 176, 528–535.

Poster Presentation Number 101, Session 2, Friday 14:00 - 15:30

## From the Late to the Middle Pleistocene: a chronological reassessment of the Neanderthal Navalmaíllo rock shelter (Madrid, Spain)

Virginia Martínez-Pillado<sup>1</sup>, Lee Arnold<sup>2</sup>, José Eugenio Ortiz<sup>3</sup>, Christophe Falguères<sup>4</sup>, Martina Demuro<sup>2</sup>, Trinidad Torres<sup>3</sup>, Mathieu Duval<sup>5,6,7</sup>, Olivier Tombret<sup>4,8</sup>, David Martín-Perea<sup>9,10,11</sup>, César Laplana<sup>12,13</sup>, Abel Moclán<sup>14,10</sup>, Belén Márquez<sup>13</sup>, Rosa Huguet<sup>9,15,16</sup>, Alfredo Pérez-González<sup>11</sup>, Enrique Baquedano<sup>11,13</sup>, Juan Luis Arsuaga<sup>1,10</sup>

1 - Centro Mixto UCM-ISCHH sobre Evolución y Comportamiento Humanos, Madrid, Spain · 2 - School of Physics, Chemistry and Earth Sciences, Environment Institute, and Institute for Photonics and Advanced Sensing (IPAS), University of Adelaide, Australia · 3 - E.T.S. de Ingenieros de Minas y Energía, Universidad Politécnica de Madrid, Spain · 4 - Histoire Naturelle de L'Homme Préhistorique (HNHP UMR 7194), MNHN-CNRS-UPVD, Paris, France · 5 - Centro Nacional de Investigación sobre Evolución Humana-CENIEH, Burgos, Spain · 6 - Australian Research Centre for Human Evolution, Griffith University, Brisbane, Australia · 7 - Palaeoscience Labs, Dept. Archaeology and History, La Trobe University, Melbourne, Australia · 8 - Laboratoire Archéologie et Archéométrie (ArAr, UMR 5138), CNRS, Lyon, France · 9 - IPHES-CERCA, Institut Català de Paleoecologia Humana i Evolució Social, Tarragona, Spain · 10 - Department of Geodynamics, Stratigraphy and Palaeontology, Faculty of Geology, Complutense University of Madrid, Madrid, Spain · 11 - Institute of Evolution in Africa, Madrid, Spain · 12 - ARQUEOPALEO Group, Department of Geology, Geography and Environmental Sciences, University of Alcalá, Alcalá de Henares, Spain · 13 - Museo Arqueológico y Paleontológico de La Comunidad de Madrid, Alcalá de Henares, Spain · 14 - PALEVOPRIM lab, UMR 7262 CNRS and Université de Poitiers, Poitiers, France · 15 - Departament d'Història i Història de L'Art, University Rovira i Virgili, Tarragona, Spain · 16 - Unit Associated With CSIC, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales, Madrid, Spain

The archaeological site of Navalmaíllo (Pinilla del Valle, Madrid, Spain) is located in a huge rock shelter approximately 6-7 metres above the Valmaíllo riverbed. Its stratigraphic infill preserves at least three levels of Neanderthal occupation, among which Level F stands out for its dense archaeological record. This level contains substantial hearth structures, as well as spatially concentrated faunal and lithic remains, indicative of a structured use of space. The lithic assemblage is typically Mousterian, comprising tools such as points, picks, denticulates, and scrapers, with a notable predominance of quartz and a marked tendency toward microlithism. The faunal assemblage is dominated by large herbivores such as large bovines, red deer, horses, and steppe rhinoceroses. Numerous cut marks and green bone fractures provide clear evidence of butchery and meat processing, supporting the interpretation of the site as a hunting camp.

Until now, Level F had been dated to approximately 72–77 ka based on thermoluminescence (TL) analyses conducted at the Universidad Autónoma de Madrid (UAM). However, the reliability of this laboratory's older results has been questioned in recent years due to potential methodological and equipment calibration issues. In the present study, a new numerical dating programme was undertaken, combining multiple independent techniques (US-ESR, OSL, TT-OSL, and AAR) to establish a robust chronological framework for this level. The results obtained across all methods are internally consistent, yielding ages between 165 and 187 ka. These new dates significantly revise the site's chronology, pushing its occupation back by approximately 100,000 years and firmly placing it within the late Middle Pleistocene.

This reassessment not only alters the temporal framework of the Navalmaíllo site, but also reinforces its relevance within the broader context of the Middle Pleistocene Neanderthal occupations in the Iberian Peninsula. The new chronology aligns it with other well-dated Early Middle Palaeolithic sites, contributing valuable data to future discussions on Neanderthal behavioral evolution during this period.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Reconstructing dietary preferences in the Middle Pleistocene Sima de los Huesos population

**Laura Martín-Francés<sup>1,2</sup>, María Martín-Torres<sup>2,3</sup>, Marina Lozano<sup>4,5</sup>, María Hernaiz-García<sup>2,6</sup>, Juan Luis Arsuaga<sup>7,8</sup>, José María Bermúdez de Castro<sup>1</sup>, Luca Fiorenza<sup>2</sup>**

1 - CENIEH (Centro Nacional de Investigación sobre la Evolución Humana), Burgos, Spain · 2 - Monash Biomedicine Discovery Institute, Department of Anatomy and Developmental Biology, Monash University, Melbourne, Australia · 3 - Anthropology Department, University College London, London, UK · 4 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain · 5 - Departament d'Història i Història de l'Art, Universitat Rovira i Virgili (URV), Tarragona, Spain · 6 - Laboratorio de Poblaciones del Pasado (LAPP), Facultad de Ciencias, Departamento de Biología, Universidad Autónoma de Madrid (UAM), Madrid, Spain · 7 - Centro UCM-ISCIII de Evolución y Comportamiento Humanos, Madrid, Spain · 8 - Departamento de Geodinámica, Estratigrafía y Paleontología, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Madrid, Spain

Molar macrowear analysis is a valuable tool for inferring dietary preferences ultimately aiding in the reconstruction of subsistence strategies and palaeoenvironmental conditions [1]. Chewing involves two phases, each producing distinct wear facets whose relative development has been linked to dietary preferences and ecological contexts [1-3]. Dating suggests that the Sima de los Huesos (SH) population lived during MIS 12, one of the coldest global periods [4]. We reconstruct the dietary habits of the SH group to test whether their macrowear pattern reflects the MIS 12 environmental conditions.

To reconstruct masticatory behaviour, we employed Occlusal Fingerprint Analysis (OFA) method [3] on the 3D polygonal models of the SH maxillary molars (7 M1s and 9 M2s). We calculated: i. relative wear facet areas; and, ii. wear inclination by measuring the angle the reference plane and the facet plane. SH results were compared to those of Neanderthals, Upper and Middle Paleolithic *H. sapiens*, and modern humans from different geographical regions and chronologies [1,5]. To assess environmental conditions, SH results were compared to the sample grouped into three ecogeographical contexts: steppe/coniferous forest, Mediterranean evergreen, and deciduous woodland [1]. A one-way PERMANOVA test assessed overall differences, with significant results further examined using Mann-Whitney U test. To examine wear facet inclination, a proxy for dietary abrasiveness and masticatory load, groups were classified by techno-complex, applying Kruskal-Wallis and Mann-Whitney U tests for comparisons.

SH macrowear is dominated by phase I buccal facets (41%), followed by phase II (32%) and lingual phase I facet (28%) areas. Mann-Whitney test showed a significant difference in lingual phase I facets between the SH and Steppe/Coniferous groups. SH maxillary molars exhibit steeper shearing wear facets (buccal and lingual phase I) compared to grinding (phase II) wear facets. Mann-Whitney test showed significant differences in buccal phase I inclination between SH and all groups, and in lingual phase I inclination between SH and modern hunter-gatherers (MHG).

Larger buccal phase I facets in SH maxillary molars are associated with a diet dominated by animal proteins [1] and the large lingual phase I facets suggests the consumption of plant material as well. The significant difference in buccal phase I inclination between SH and the other groups, and in lingual phase I inclination between SH and MHG group, suggests a less abrasive diet for the SH population.

Overall, OFA results indicate that the Sima de los Huesos population had a mixed diet, with similar proportions of meat and plant foods. This dietary pattern does not reflect a strictly cold environment, but a diverse landscape as suggested by palaeocological proxies including pollen, fauna and isotopic data.

We acknowledge all members of the Atapuerca research and archaeological team for their valuable contributions. We sincerely thank Dr. Palmira Saladié (IPHES) and Dr. Andreu Ollé (IPHES) for their valuable insights and constructive feedback. The authors gratefully thank the curators and institutions which allowed us to study comparative and fossil specimens: Almut Hoffmann (Museum für Vor- und Frühgeschichte, Berlin, Germany), Maria Teschler Nicola (Naturhistorisches Museum Wien, Vienna, Austria), Marta Dócalová (Moravské Zemské Muzeum, Anthropos Institute, Brno, Czech Republic), Bence Viola (Department of Anthropology, University of Vienna, Austria), Yoel Rak (Department of Anatomy and Anthropology, University of Tel Aviv, Israel), Fabio Parenti (Istituto Italiano di Paleontologia Umana, Rome, Italy), Chris Stringer and Rob Kruszynski (Natural History Museum of London, England), Angiolo del Lucchese (Museo Preistorico dei Balzi Rossi, Ventimiglia, Italy), and Erik Trinkaus (Department of Physical Anthropology at Washington University in Saint Louis, USA). We also would like to thank Christine Hemm for her help in surface scanning the original and cast dentition included in this sample.

This work is supported by the Horizon Program-Marie Skłodowska-Curie Actions of the EU Ninth programme (2021–2027) under the HORIZON-MSCA-2021-PF-01-Project: 101060482; the Spanish Ministry of Science and Innovation and European Regional Development Fund “ERDF A way of making Europe” (projects PID2021-122355NB-C31, PID2021-122355NB-C32, PID2021-22355NB-C33). Fieldwork is supported by the Junta de Castilla y León and the Fundación Atapuerca. L.M-F receives funding from the EU-Horizon Program-Marie Skłodowska-Curie Actions of the EU Ninth programme (2021–2027) under the HORIZON-MSCA-2021-PF-01-Project: 101060482. M.M-T. receives funding from The Leakey Foundation through the personal support of D. Crook. M.H-G. received funding from the Biomedicine Discovery Scholarship (Monash University) and project SI4/PJ1/2024-00104 (Universidad Autónoma de Madrid and the Comunidad de Madrid). The SH dental remains were scanned at the Microscopy and Micro-CT laboratory of the CENIEH-ICTS with the support of the staff.

References: [1] Fiorenza, L., 2015. Reconstructing diet and behaviour of Neanderthals from Central Italy through dental macrowear analysis. *Journal of Anthropological Sciences*. 93, 119-133. [2] Kay, R.F., Hiiemae, K.M., 1974. Jaw movement and tooth use in recent and fossil primates. *American Journal of Physical Anthropology*. 40, 227-256. [3] Kullmer, O., Benazzi, S., Fiorenza, L., Schulz, D., Bascio, S., Winzen, O., 2009. Technical note: Occlusal fingerprint analysis: Quantification of tooth wear pattern. *American Journal of Physical Anthropology*. 139, 600-605. [4] Demuro, M., Arnold, L.J., Aranburu, A., Sala, N., Arsuaga, J.-L., 2019. New bracketing luminescence ages constrain the Sima de los Huesos hominin fossils (Atapuerca, Spain) to MIS 12. *Journal of Human Evolution*. 131, 76-95. [5] Fiorenza, L., Kullmer, O., 2013. Dental wear and cultural behavior in Middle Paleolithic humans from the Near East. *American Journal of Physical Anthropology*. 152, 107-117.

Podium Presentation, Session 6, Friday 16:00 – 17:40

## Early Pleistocene human settlement of Europe: new evidence from Atapuerca-Sima del Elefante (Burgos, Spain)

Maria Martín-Torres<sup>1,2</sup>, Elena Santos<sup>1,3</sup>, Laura Martín-Francés<sup>1,4</sup>, José M. Bermúdez de Castro<sup>1</sup>, Marina Lozano<sup>5,6</sup>, Xose P. Rodríguez-Álvarez<sup>6,5</sup>, Rosa Huguet<sup>5,6,7</sup>

1 - CENIEH (Centro Nacional de Investigación sobre la Evolución Humana), Burgos, Spain · 2 - Anthropology Department, University College London, London, UK · 3 - Centro Mixto UCM-ISCIII de Evolución y Comportamiento Humanos, Madrid, Spain · 4 - Department of Anatomy and Developmental Biology, Monash University, Melbourne, Victoria, Australia · 5 - Institut Català de Paleoeccologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain · 6 - Universitat Rovira i Virgili, Departament d'Història i Història de l'Art, Tarragona, Spain · 7 - Unit Associated to CSIC, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain

The Atapuerca sites (Burgos, Spain) have yielded the most abundant and well-constrained evidence of human presence in Western Europe during the Early Pleistocene. Two key localities —Gran Dolina and Sima del Elefante— have produced significant archaeological and paleoanthropological remains that are critical to understanding the initial human settlement of the continent. In 1997, *Homo antecessor* was named as a new species based on over one hundred fossils from Gran Dolina (TD6), dated to approximately 860,000 years ago [1]. One of the most distinctive features of *Homo antecessor* is its gracile, modern-like midfacial topography, characterized by the coronal orientation of the infraorbital plate. This configuration contrasts with the more primitive, anteriorly projecting faces seen in most contemporaneous populations from Africa and Asia. Morphological and molecular analyses support an ancestral position for *Homo antecessor* relative to *H. sapiens*, *H. neanderthalensis* and Denisovans.

In 2008, a hominin mandible from Sima del Elefante (TE9), dated to ~1.2 million years ago, was published and attributed to *Homo* sp., pushing back the known date of human presence in Western Europe by about 300,000 years [2]. The specimen, labelled ATE9-1 exhibited primitive features in the anterior region of the symphysis, while the internal aspect was unexpectedly derived for its chronology, showing a slight alveolar prominence and a subvertical alveolar planum. This combination suggested a departure from the morphologies observed in other Early Pleistocene hominin groups and pointed to a possible European speciation event. However, the available evidence was not enough to support a definitive taxonomic assignment.

Here we present a new fossil recovered in 2022 from the TE7 level of Sima del Elefante, two stratigraphic units below TE9. The specimen, labelled ATE7-1, consists of a partial adult midface with morphological features that clearly differ from *H. antecessor*, particularly in the infraorbital region [3]. Furthermore, the specimen is characterised by a number of similarities but also some significant differences with fossils that are generally referred to as *H. erectus sensu lato*. Pending further evidence from Sima del Elefante site or/and other contemporary sites, ATE7-1 has been provisionally assigned to *H. affinis erectus* [3]. This finding confirms the presence of at least two distinct hominin populations in Western Europe during the Early Pleistocene and raises new questions about the origin, diversity and evolutionary dynamics of the earliest settlers of the continent.

We acknowledge the members of the Atapuerca research team. The research of the Atapuerca sites is funded by the Spanish Ministry of Science and Innovation and European Regional Development Fund “ERDF A way of making Europe” (projects PID2021-122355NB-C31, PID2021-122355NB-C32, PID2021-22355NB-C33), Catalan Government (AGAUR, project 2021-SGR-01239) and Universitat Rovira i Virgili (2023PFR-URV-01239). Fieldwork at Sima del Elefante is supported by the Junta de Castilla y León and the Fundación Atapuerca. M.M.-T receives funding from The Leakey Foundation through the personal support of W.D. Crook. L.M.-F receives funding from the EU-Horizon Program-Marie Skłodowska-Curie Actions of the EU Ninth programme (2021–2027) under the HORIZON-MSCA-2021-PF-01-Project: 101060482. The hominin analyses were carried out at the laboratories of the CENIEH-ICTS and the IPHES-CERCA with the support of the CENIEH and IPHES-CERCA staff.

References: [1] Bermúdez de Castro, J.M., Arsuaga, J.L., Carbonell, E., Rosas, A., Martínez, I., Mosquera, M., 1997. A Hominid from the Lower Pleistocene of Atapuerca, Spain: Possible Ancestor to Neandertals and Modern Humans. *Science*. 276, 1392–1395. [2] Carbonell, E., Bermúdez de Castro, J.M., Parés, J.M., Pérez-González, A., Cuenca-Bescós, G., Ollé, A., Mosquera, M., Huguet, R., van der Made, J., Rosas, A., Sala, R., Vallverdú, J., García, N., Granger, D.E., Martín-Torres, M., Rodríguez, X.P., Stock, G.M., Vergès, J.M., Allué, E., Burjachs, F., Cáceres, I., Canals, A., Benito, A., Díez, C., Lozano, M., Mateos, A., Navazo, M., Rodríguez, J., Rosell, J., Arsuaga, J.L., 2008. The first hominin of Europe. *Nature*. 452, 465–469. [3] Huguet, R., Rodríguez-Álvarez, X.P., Martín-Torres, M., Vallverdú, J., López-García, J.M., Lozano, M., Terradillos-Bernal, M., Expósito, I., Ollé, A., Santos, E., Saladié, P., de Lombera-Hermida, A., Moreno-Ribas, E., Martín-Francés, L., Allué, E., Núñez-Lahuerta, C., van der Made, J., Galán, J., Blain, H.-A., Cáceres, I., Rodríguez-Hidalgo, A., Bargalló, A., Mosquera, M., Parés, J.M., Marín, J., Pineda, A., Lordkipanidze, D., Margveslashvili, A., Arsuaga, J.L., Carbonell, E., Bermúdez de Castro, J.M., 2025. The earliest human face of Western Europe. *Nature*. 640, 707–713.

Poster Presentation Number 102, Session 2, Friday 14:00 - 15:30

## The role of applying developmental simulation on mandibular corpus morphology to aid taxonomic identification

Jason S. Massey<sup>1</sup>, Irisa Arney<sup>2</sup>, Cesar Cornejo Ochoa<sup>2</sup>

1 - Department of Anatomy and Developmental Biology, Biomedicine Discovery Institute, Faculty of Medicine, Nursing, and Health Sciences, Monash University · 2 - Western University of Health Sciences, COMP-NW

Juvenile specimens are crucial to the hominin record as they provide insights into the ontogenetic processes of extinct species. Correctly identifying juvenile fossils to taxon is essential to assessing the evolution of development. Developmental simulation visualizes what a juvenile fossil might look like as an adult, aiding in proper taxonomic identification. This method uses Procrustes shape coordinates of juvenile specimens and projects them along a developmental trajectory derived from related species [1]. Previous analyses have shown that simulated adults (adult coordinates derived from juveniles) align closely with true adult morphology, provided a developmental trajectory of a closely related species is used [1-3]. The success of this method is due to the robustness of the juvenile shape to align with its true species regardless of the developmental trajectory used [1]. However, most studies investigating and utilizing developmental simulation have focused on cranial morphology. The adult cranium is a highly complex element derived from the fusion of multiple, independently developing bony regions. In contrast, the adult mandible has less complexity in its morphology. This study aims to discern whether developmental simulation can also be used on mandibular anatomy to further analyses into mandibular developmental evolution.

This study used an ontogenetic sample of 256 specimens belonging to 4 hominoid taxa (two species of *Gorilla* and two species of *Pan*). Landmarks were chosen to capture relevant mandibular corpus morphology typically represented in the fossil record and diagnostic for taxonomic identification. Ontogenetic trajectories were calculated for each species and compared to investigate differences in the pattern and magnitude of development. Procrustes coordinates of juvenile mandibles (developmental stage dP4) were projected along non-linear growth trajectories derived from each species to simulate adult anatomy. These simulated adults were compared to the mean of true adults to ascertain if this method could be used to 'grow up' juvenile fossils to a standard that could aid assigning taxonomic affinity.

Differences in adult morphology between *Gorilla* and *Pan* arise from the magnitude of shape change (i.e., more development occurs in *Gorilla* at each developmental stage). While developmental trajectories between the two species of *Gorilla* are not statistically different, statistical differences in *Pan* are mediated through different patterns of shape change along the trajectory. Finally, simulated adults group nearest to their true adult averages only if the matching species' trajectory used. If alternative trajectories are used to simulate adults, the resulting shape does not consistently represent the morphology of the parent species.

We would like to thank the museums for allowing access to these important collections: Powell-Cotton Museum, Musée Royal de L'Afrique Centrale, and the Cleveland Museum of Natural History.

References: [1] McNulty, K.P., Frost, S.R., Strait, D.S., 2006. Examining affinities of the Taung child by developmental simulation. *Journal of Human Evolution*. 51, 274–296. [2] Singleton, M., McNulty, K.P., Frost, S.R., Soderberg, J., Guthrie, E.H., 2010. Bringing up baby: Developmental simulation of the adult cranial morphology of *Rungwecebus Kipunji*. *The Anatomical Record*. 293, 388–401. [3] Carlson, K.B., de Ruiter, D.J., DeWitt, T.J., McNulty, K.P., Carlson, K.J., Tafforeau, P., Berger, L.R., 2016. Developmental simulation of the adult cranial morphology of *Australopithecus sediba*. *South African Journal of Science*. 112, 9.

Poster Presentation Number 103, Session 2, Friday 14:00 - 15:30

## Between the Lower and Middle Palaeolithic in the northern Pyrenees: the case of the Coupe-Gorge (Montmaurin sites-complex, France)

Cyrielle Mathias<sup>1,2</sup>, Amélie Vialet<sup>3</sup>

1 - University of Perpignan, UMR 7194 - Histoire Naturelle des Humanités Préhistoriques · 2 - Centre de recherche français à Jérusalem · 3 - Muséum National d'Histoire Naturelle, UMR 7194 - Histoire Naturelle des Humanités Préhistorique Abstract:

Palaeolithic human occupations remain relatively rare in the Pyrenean region, likely due to preservation biases. While several sites provide reliable chronostratigraphic contexts for the Late Middle Palaeolithic (e.g., Le Noisetier, Gatzarria, Mauran, Le Portel), evidence for earlier Palaeolithic settlements in the Pyrenees and its Piedmont remains sparse. In this context, the Montmaurin karstic complex (Haute-Garonne) emerges as a key locality for investigating hominin biology, behaviour, and evolutionary dynamics during the second half of the Middle Pleistocene.

Multiple caves and rock shelters within this complex—such as Boule, La Niche, La Terrasse, Coupe-Gorge, and Les Putois—have yielded archaeological deposits (including human remains) spanning the Lower, Middle, and even Upper Palaeolithic [1]. Among them, the Coupe-Gorge site is particularly noteworthy for its rich stratigraphic sequence, initially uncovered in the mid-20th century during quarrying operations. Excavations led by L. Méroc between 1946 and 1961 revealed at least seven cultural layers for the unit 3, originally attributed to the Lower Palaeolithic and comprising thousands of artefacts [2]. Reinvestigating such legacy collections poses significant challenges. To address this, a renewed multidisciplinary research program has been underway since 2018 under the direction of A. Vialet. This initiative integrates excavation, dating, raw material analysis, and geomorphological surveys.

Preliminary findings indicate a substantial archaeological sequence attributable to the early Middle Palaeolithic. Layer 3Z, dating to MIS 6, reflects intensive human occupation and yielded 2 human remains (a fragment of an immature mandible and an isolated tooth – ULP3). While deeper layers suggest more episodic occupations dating back to MIS 7 and earlier where a right maxillary bone bearing C-P4 was discovered together with 2 isolated teeth (LRM3 and ULC). Throughout the sequence, a consistent use of Discoid technology is observed on both local quartzite and flints. The presence of bifacial tools and other shaped implements indicates a marked adaptation to raw material constraints, including the use of core-on-flake strategies, splits, and other recycling phenomenon.

The human remains are attributed to Neanderthals. However, the maxilla from the lower levels, dated to 300 ka, does not show the marked prognathism expected for a Neanderthal. Its conformation is closer to fossils such as Arago 21 (Tautavel, France) dated around 450 ka, although the internal and external features of its teeth are evolved (Neandertal-like). From a techno-cultural perspective, the Coupe-Gorge assemblages reveal notable divergences from later regional traditions employing similar technologies [3]. These findings contribute to a more nuanced understanding of the Lower to Middle Palaeolithic transition in the Pyrenean context—one that challenges the conventional emphasis on the Levallois concept as a defining hallmark of this shift.

The data from Coupe-Gorge enrich our understanding of early Neanderthal populations and their techno-cultural practices in South-West Europe. The combination of archaic and derived traits in the human remains, coupled with non-Levallois lithic strategies adapted to local raw materials, highlights the diversity of technological and biological expressions during the Middle Pleistocene. These insights underscore the need to reassess linear models of Neanderthal evolution and behavioural development, positioning Montmaurin as a critical reference point for broader discussions on hominin variability and regional trajectories across Europe.

We would like to thank the UMR 7194 - HNHP and all the organisations financing the excavations at Montmaurin (SRA Occitanie, Occitanie region and Haute-Garonne department) as well as the excavation and scientific team. This work is also part of a funded project 'Défi-clé Sciences du Passé' of the Occitanie region (Gorgyous; dir. A. Vialet & C. Pallier).

References: [1] Vialet, A., Bertrand, B., Champalle, C., Bermúdez de Castro, J.-M., Modesto-Mata, M., Martínón-Torres, M., Martínez de Pinillos, M., García Campos, C., Martín-Francés, L., Colard, T. 2019. Re-examination of "ancient" fossils discovered in the middle of the 20th century. Hominins from the end of the Middle Pleistocene from the Montmaurin caves (southwest of France). *The Journal of the International Union for Prehistoric and Protohistoric Sciences*. 2, 32-37. [2] Gaillard, C. 1982. L'industrie lithique du Paléolithique inférieur et moyen de la grotte de Coupe-Gorge à Montmaurin (Haute-Garonne). *Gallia préhistoire*. 25, 79-105. [3] Thiébaud, C., Mourre, V., Chalard, P., Colonge, D., Coudenneau, A., Deschamps, M., Sacco-Sonador, A., 2012. Lithic technology of the final Mousterian on both sides of the Pyrenees. *Quaternary International*. 247, 182-198.

Poster Presentation Number 104, Session 2, Friday 14:00 - 15:30

## New probably Late Neandertals from Castaigne Cave (Torsac commune, Charente, France): inventory, biology and behaviors

Bruno Maureille<sup>1</sup>, Saïoa Garcia Liebana<sup>1</sup>, Juliette Henrion<sup>1</sup>, Stéphane Madelaine<sup>1,2</sup>, Maryelle Bessou<sup>1</sup>, Nicolas Vanderesse<sup>1</sup>, Christine Couture-Veschambre<sup>1</sup>

1 - Univ. Bordeaux, CNRS, Ministère de la Culture, PACEA, UMR 5199, Pessac, France · 2 - Musée National de Préhistoire, Les Eyzies-de-Tayac

In southwestern France, it is rare for palaeolithic sites excavated between the 1960s and 1980s –especially those yielding human remains attributed to the Upper Pleistocene– to have escaped the attention of the scientific community. Yet this appears to be the case for the remains uncovered during fieldwork at Castaigne Cave (Torsac, Charente), located on the right bank of the Eaux Claires Valley, near the well-known sites of Petit Puymoyen. The prehistoric interest of Castaigne Cave was first highlighted in 1961 by Louis Duport [1], who continued field investigations there until 1968. The results of his work were only sparsely published. One of his articles mentions the discovery of 31 human remains, including approximately fifteen isolated teeth, as well as cranial and infracranial remains [2]. In 1980, Erik Trinkaus had the opportunity to examine some of these teeth, likely at the University of Jussieu (Paris, France).

In 2018 and 2019, we initiated a re-evaluation of this site. The lithostratigraphy is "relatively" simple, with Paleolithic materials coming from layer 2, presumed to be Mousterian in context. However, the faunal assemblages include numerous post-Paleolithic pieces. We therefore resumed the analysis of the archaeological, faunal, and paleoanthropological collections of the site [3,4]. Considering human fossils, we now identify 21 isolated teeth, of which 18 are attributed to Neandertals, along with at least five cranial and five infracranial fragments likely of human origin. The dental assemblage suggests the presence of at least seven different Neandertal individuals, spanning age classes from early childhood (infans I) to middle-aged adults. We will provide a brief description of the cranial and infracranial remains and highlight selected results from external morphological and metric analyses, as well as internal structural assessments, of some isolated Neandertal teeth. Moreover, behavioral evidences –i.e., toothpick grooves– are also observed, affecting the morphology of 10 teeth representing at least three different individuals.

In terms of Neandertal variability, some teeth have notably large crowns while others are relatively small with root morphologies which seem us to differ from the "typical" Neandertal morphology. In terms of toothpick groove, the oldest individual, a middle-aged adult represented by four teeth, exhibits pronounced toothpick grooves at the cervical margin on at least one mesial or distal crown side of each tooth. Moreover, on a lower left first molar (LLM1), the toothpick grooves show a striking asymmetry between the two sides, an observation which, to our knowledge, has not been previously documented. These findings prompt questions regarding the nature and material of the implements used as a toothpicks.

A lower right lateral incisor (LRI2), from a middle-aged adult, shows distinct distal wear also consistent with toothpick use. This is rare on Neandertal single-rooted teeth, with few parallels except in material from El Sidrón (Spain) and Hortus (France) [5]. Additional wear features (striations), at minimum corresponding to stage 2 toothpick grooves as previously described [5], are also identified on mesial and distal sides on two teeth attributed to an individual who died around the beginning of its puberty.

To conclude, together, these findings suggest that from a certain age, around the beginning of the puberty, Neandertal individuals were engaged in activities –masticatory or para-masticatory– that involved or necessitated the use of a toothpick, for reasons that remain to be further explored.

We express our gratitude to the Ministry of Culture, Nathalie Fourment, Gwénaëlle Marchet-Legendre, and Christine Redien-Lairé from the Regional Archaeology Service of the Nouvelle-Aquitaine Region, as well as to Jean-Jacques Cleyet-Merle, Director of the National Museum of Prehistory, for their support in our research on the Castaigne Cave, their assistance in accessing the collections, and for granting us permission to study and sample the material. We are also indebted to Annie France Viudes, Bernard Vandermeersch, José Gomez de Soto and Bruno Boulestin for their various forms of help, including the documentation they provided on Louis Duport's research at this site. Finally, we thank Chantal Caminéro and her family for their assistance during our visits which allowed us to relocate the cave. This research received financial support from the French government in the framework of the University of Bordeaux's IdEx "Investments for the Future" program / GPR "Human Past" and from the Region Nouvelle Aquitaine scientific project ADNER (codir. P. Bayle and B. Maureille, convention no. AAPR2021-2020-11779310).

References: [1] Duport, L., 1966. Les gisements préhistoriques de la vallée des Eaux-claires (I). IX. - Le gisement moustérien de Torsac (Chte), grotte E. Castaigne. Mémoires de la Société archéologique et historique de la Charente. Année. 1965, 95-100. [2] Duport, L., Vandermeersch, B., 1965. III. Les gisements moustériens de l'abri Commont, de la grotte Simard et de la grotte Castaigne. Bulletin de l'Association Française pour l'Etude du Quaternaire. 3-4, 189-192. [3] Maureille, B., Faivre, J.-P., Gravina, B., Rigaud, S., Madelaine, S., Bessou, M., Couture-Veschambre, C., 2020. La grotte Castaigne (commune de Torsac, Charente, France). Présentation d'un site méconnu riche en vestiges humains (dont des Néandertaliens). *Paleo*. 30, 196-221. [4] Maureille, B., Madelaine, S., Rigaud, S., Faivre, J.-P., Gravina, B., Bessou, M., Couture-Veschambre, C., 2021. La grotte Castaigne (Commune de Torsac, Charente): une nécessaire révision de la provenance de certains vestiges archéologiques et fauniques. *Paleo*. 31, 188-209. [5] Estalrich, A., Alarcón, J.A., Rosas, A., 2016. Evidence of toothpick groove formation in Neandertal anterior and posterior teeth. *American Journal of Physical Anthropology*. 162, 747–756.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## Reviewing biochronology in the European Middle Pleistocene: implications for terrestrial ecosystem dynamics and human evolution

**Beniamino Mecozzi<sup>1</sup>, Marzia Breda<sup>2</sup>, Fabio Di Vincenzo<sup>1</sup>, Alessia Masi<sup>1</sup>, Marie-Hélène Moncel<sup>3</sup>, Raffaele Sardella<sup>4</sup>, Giorgio Manzi<sup>1</sup>**

1 - Department of Environmental Biology, Sapienza University of Rome, Rome, Italy · 2 - Museum of Nature and Humankind, University Museum Centre, University of Padova, Padova, Italy · 3 - UMR 7194 HNHP (MNHN-CNRS-UPVD), Département Homme et Environnement, Muséum National d'Histoire Naturelle, Paris, France · 4 - Department of Earth Science, Sapienza University of Rome, Rome, Italy

The Middle Pleistocene (MP) is a crucial period in the evolution of the terrestrial ecosystems worldwide, marked by significant climatic changes. The Early to Middle Pleistocene Transition witnessed prolonged and intensified glacial–interglacial climate cycles, shifting from 41 ka to approximately 85–125 ka. Climatic fluctuations profoundly impacted both vegetation and terrestrial mammal communities. As far as Europe is concerned, these changes mostly corresponded to increased seasonality, recurrent glaciations and aridity in the Northern Hemisphere. By considering the climate, the MP records two particularly severe glacials, Marine Isotopic Stage (MIS) 16 and MIS 12, while MIS is considered the longest and warmest interglacial in the last 800 ka.

The late Early Pleistocene is characterized by major community reorganizations occurring in successive phases during paleoenvironmental changes and strong climatic oscillations. During this period, there is a progressive dispersal of modern taxa into Europe, bringing to a considerable faunal renewal. Initially considered part of the Galerian Mammal Age, the late Early Pleistocene, between approximately 1.2 and 0.8 Ma, was later formalized as the Epivillafranchian ELMA. In this updated framework, the onset of the MP aligns with the beginning of the Galerian ELMA. The latter identified the turnover in mammalian fauna that occurred during the Early to Middle Pleistocene, which remains relevant for highlighting changes documented in Europe. These include the persistence of late Villafranchian taxa, the dispersal of several extant species, and the initial appearance and spread of Acheulean Palaeolithic complexes across the continent.

During the revision and updating of the biochronological assessment proposed by a team of Italian palaeontologists for the Late Pliocene–Quaternary terrestrial mammal, mollusc, and ostracod record of the Italian Peninsula, the last ELMA, the Aurelian, was also introduced. The European biochronology scheme of land mammals is inherently subject to revision based on new discoveries, which allow to redefine mammal turnovers, the synchronicity or a-synchronicity between bioevents, and the related biochronological correlations. Another important aspect that could prompt changes in the biochronological scheme is the diverse taxonomical attributions of certain samples. These systematic divergences may stem from either the general scarcity and fragmentary nature of the remains, or from the subjective interpretations of the authors. Lastly, advancements in dating techniques, which progressively enhance precision over time, when applied to Pleistocene contexts, may provide new chronological constraints, by reevaluating the ages of previously dated localities or establishing boundaries for sites with uncertain ages. In light of these considerations, it is evident that the biochronological scheme requires updating based on the paleontological literature published in the last decades.

We present a critical review of the biochronological distribution of continental mammals from the MP of Europe. As far as humans are concerned, following the appearance in the archaeological record of the Acheulean techno-complexes—around or before MIS 16 and likely of Africa origin—local human evolution shows Neanderthal features emerging after MIS 12, alongside with more plesiomorphic morphologies that persisted in refugial areas such as the Italian Peninsula. Newly discovered fossil assemblages, re-evaluation of historical collections, and updated radiometric dating of key European sites have significantly altered the timelines of faunal dispersals and extinction events across the continent. These developments are here critically assessed, offering an updated perspective on the evolution of European terrestrial ecosystems during the MP, in responses to climatic fluctuations, and in their interaction with early human populations.

Poster Presentation Number 105, Session 2, Friday 14:00 - 15:30

## Ecology and paleoenvironments of *Paradolichopithecus* (Primates, Cercopithecidae) at Dafnero, a Lower Pleistocene site of Greece

Gildas Merceron<sup>1</sup>, Evangelia Alifieri<sup>2</sup>, Emilie Berlioz<sup>3</sup>, Anastasia Gkeme<sup>2</sup>, Laurent Grasset<sup>4</sup>, Christos-Alexandros Plastiras<sup>2</sup>, Thomas Tütken<sup>5</sup>, Hubert Vonhof<sup>6</sup>, Dimitris S. Kostopoulos<sup>2</sup>

1 - PALEVOPRIM Lab, UMR 7262 CNRS and University of Poitiers, France · 2 - Laboratory of Geology and Palaeontology, Aristotle University of Thessaloniki, Thessaloniki, Greece · 3 - Research Group I+D+i EvoAdapta, Department of Historical Sciences, University of Cantabria, Santander, Spain · 4 - IC2MP, UMR 7285 CNRS & University of Poitiers, France · 5 - Applied and Analytical Paleontology, Institute of Geosciences, Johannes Gutenberg University, Mainz, Germany · 6 - Department of Climate Geochemistry, Max Planck Institute for Chemistry, Mainz, Germany

During the Early Pleistocene, primates in Europe were represented by macaques and a large monkey referred to *Paradolichopithecus*. The body mass of the latter exceeds known ranges of *Macaca* [1], indicating this taxon falls into size classes comparable to those of extant baboons while adopting a similarly terrestrial way of life [2,3]. In Greece *Paradolichopithecus* is known from Dafnero-3, Vatera, and Karnezeika sites, all bearing middle Villafranchian faunas [1].

To characterize the environment of *Paradolichopithecus* at Dafnero, we combine here botanical palaeochemotaxonomy as a complementary proxy for palaeoflora and palaeoclimate [4] reconstruction along with the dietary guild of the primary consumers: equids, bovids and cervids as inferred by dental microwear texture analysis (DMTA; n=36) with carbon stable isotope analysis of enamel sequentially sampled along tooth crown height of third molars (n=15). Enamel carbon stable isotope composition ( $\delta^{13}\text{C}_{\text{enamel}}$ ) highlights metabolic pathways of the plants eaten as teeth were mineralizing, while dental microwear textures reflect the physical properties of the food of the few weeks before death.

When looking at individual mean  $\delta^{13}\text{C}_{\text{enamel}}$  for all species, they range from -12.2‰ to -9.5‰ VPDB, with the highest mean values found for the cervid *Metacervoceros* ( $\delta^{13}\text{C} = -9.9\text{‰}$  VPDB; n=2) and the lowest for the antelope *Gazellospira* ( $\delta^{13}\text{C} = -11.68$ ; n=3). This depicts a C3 plant-dominated environment. The absence of low values for any of the six species of ungulates rather advocates for open environmental conditions. None of these species had occupied forested habitat with a dense tree canopy. Looking at the serial values along tooth crown, the widest dispersion is found for the cervid *Eucladoceros* ( $\delta^{13}\text{C}$  from 1.39 to 3.12‰; n=3), and the smallest for the antelope *Gazellospira* ( $\delta^{13}\text{C}$  from 0.70 to 0.89‰; n=3). This suggests that all of these taxa kept foraging on C3 plants all around the year at Dafnero. DMTA was run on molars. Using scale sensitive fractal analysis, we found out that the Dafnero equid displays the smallest mean value in complexity and an intermediate one in anisotropy ( $A_{\text{SFC}} = 1.26$  and  $epL_{\text{SAR}} = 0.00394$ ; n=10). Besides, the sample of the antelope *Gazellospira* (n=12) have higher mean value in complexity and intermediate one in anisotropy ( $A_{\text{SFC}} = 2.08$  and  $epL_{\text{SAR}} = 0.00346$ ). This would rather support that the equid was more engaged in grazing than the antelope, which share similar values with mixed feeding present-day species like mouflons. The specimen number of cervids is low. However, both *Eucladoceros* and *Metacervoceros* show high values of anisotropy ( $epL_{\text{SAR}} > 0.005$ ). Also, it is worth noting that *Metacervoceros* displays wide range of values in complexity ( $A_{\text{SFC}}$  from 0.88 to 3.70; n=4). We could conclude that the two cervids had a more diverse diet than *Equus* and *Gazellospira*; they likely included fruits and seeds as modern deer used to browse on. However, the high values of anisotropy would rather discard the consumption of hard lignified material such as bark. The analysis of lipid biogeomarkers, as traces in the surrounding sediment, is not in contradiction with these previous results. Indeed, lipids are mainly composed of waxy n-alkanes in the C15-C37 range. Fatty acids, sterols (mostly phytosterol), n-alkan-1-ols and a series of aromatics typical of charred wood residues have also been identified.

Our results 1) suggest a C3 dominated environment, 2) confirm the presence of browse accessible to medium sized ungulates, but 3) exclude the existence of dense forested areas, and 4) attest the presence of C3 monocotyledonous in a wealthy herbaceous layer. Our findings are in line with post cranial evidences [2], molar morphology and dental microwear textures [5] that together depicts *Paradolichopithecus* as an open landscape dwelling monkey.

Excavations at Dafnero were supported by the CNRS, France [grant numbers PIC5185; 2010–2013 and IEAPICS08245; 2019–2021]; and the National Geographic Society [grant 9903-16; 2016–2017]. DSK and GM are grateful to Em. Prof. GD Koufos and all members of the field team.

References: [1] Kostopoulos, D.S., Guy, F., Kynigopoulou, Z., Koufos, G.D., Valentin, X., Merceron, G., 2018. A 2Ma old baboon-like monkey from Northern Greece and new evidence to support the *Paradolichopithecus* – *Procyonophalus* synonymy (Primates: Cercopithecidae). *Journal of Human Evolution*. 121, 178–192. [2] Van der Geer, A.A.E., Sondaar, P.Y., 2002. The postcranial elements of *Paradolichopithecus avernensis* (Primates, Cercopithecidae, Papionini) from Lesvos, Greece. *Annales géologiques des Pays helléniques*. 39, 71–86. [3] Le Maitre, A., Guy, F., Merceron, G., Kostopoulos, D.S., 2022. Morphology of the bony labyrinth supports the affinities of *Paradolichopithecus* with the Papionina. *International Journal of Primatology*. 44, 209–236. [4] van Aarsen, B.G.K., Alexander, R., Kagi, R.L., 2000. Higher plant biomarkers reflect palaeovegetation changes during Jurassic times. *Geochimica et Cosmochimica Acta*. 64, 1417–1424. [5] Plastiras, C.-A., Berlioz, E., Merceron, G., Guy, F., Kostopoulos, D.S., 2017. Exploring the feeding ecology and habitat of the primate from Dafnero-3. 5th Congress of the Regional Committee of the Mediterranean Neogene Stratigraphy, Athens, Greece.

Poster Presentation Number 106, Session 2, Friday 14:00 - 15:30

## Edge sharpness does not vary between Palaeolithic flake technologies, with the exception of Levallois *débitage*

Anna Mika<sup>1</sup>

1 - Department of Archaeology, University of Cambridge, Cambridge, United Kingdom

Identifying why hominin populations preferentially produced one flake technology over another is pivotal to understanding lithic technological change in the mid-to-late Pleistocene. This is not only a question related to artefact typology or chronology, but also reflects deeper behavioural, cognitive, anatomical, and adaptive shifts in our evolutionary past. At a fundamental level, two key transitions in flake technologies occur during this period. First, Levallois flake technologies emerged c. 350,000 - 250,000 years ago in Eurasia and Africa, replacing what was previously a focus on expedient flake technologies. Following this, blade technologies emerge and replace Levallois flakes in spatially and temporally variable ways, but most markedly from c. 45,000 years ago in Europe and Africa. To explain these transitions, studies have previously focused on technological differences and efficiencies, or how each flake type could be used, with few directly comparing their functional performance. No studies have investigated their comparative sharpness – a characteristic that has been attributed to cutting performance.

In this study, we address this gap by experimentally comparing the edge sharpness of expediently produced flakes, Levallois flakes, Levallois *débitage*, blades, and bladelets using controlled cutting tests. Results reveal no significant differences between formal flake categories, with expedient, Levallois, blade and bladelet flakes displaying similar sharpness measures; Levallois *débitage*, however, was significantly blunter than all four. These data suggest there to be significant costs to using *débitage* flakes as a cutting tool. We tentatively suggest these performance differences could derive from micromorphological differences at the edge apex. Equally, our data suggests that varying edge sharpness – and its associated impact on cutting performance – was not a contributing factor behind the emergence of Levallois, blade and bladelet technologies.

This research contributes to ongoing debates about the cognitive and behavioural capabilities of Pleistocene hominins. The adoption of new technologies is often viewed as evidence of increasing cognitive complexity and adaptability to changing resources and/or environments. However, our results emphasise that technological transitions were not necessarily tied to improvements in tool performance, at least in terms of sharpness. This underscores the importance of considering broader ecological, cultural, and/or other functional dynamics when studying hominin behaviour.

This work was supported by the University of Cambridge Harding Distinguished Postgraduate Scholars Programme, and the UKRI Arts and Humanities Research Council (AHRC) Capability for Collections (CapCo) Fund for the Cambridge Heritage Science Hub (CHERISH) Initiative (AH/V011685/1).

Poster Presentation Number 107, Session 2, Friday 14:00 - 15:30

## New investigations at the Lower Paleolithic site of Notarchirico (Italy). A time window between 700 and 600 ka on human dispersal in Western Europe

Marie-Hélène Moncel<sup>1</sup>, Marta Arzarello<sup>2</sup>, Jean-Jacques Bahain<sup>1</sup>, Claudio Berto<sup>3</sup>, Marco Carpentieri<sup>1</sup>, Fabio Di Vincenzo<sup>4</sup>, Giacomo Eramo<sup>5</sup>, Giovanna Fioretti<sup>5</sup>, Paula Garcia-Medrano<sup>1</sup>, Bruce Hardy<sup>6</sup>, Alessio Iannucci<sup>7</sup>, Cristina Lemorini<sup>8</sup>, Flavia Marinelli<sup>8</sup>, Giorgio Manzi<sup>9</sup>, Beniamino Mecozzi<sup>10</sup>, Ileana Micarelli<sup>11</sup>, Sébastien Nomade<sup>12</sup>, Alison Pereira<sup>13</sup>, Antonio Pineda<sup>14</sup>, Rivka Rabinovich<sup>15</sup>, Lilian Reiss<sup>1</sup>, Valentin Rineau<sup>16</sup>, Raffaele Sardella<sup>17</sup>, Pierre Voinchet<sup>1</sup>, Valéry Zeitoun<sup>16</sup>

1 - UMR 7194 HNHP, Département Homme et Environnement, Muséum National d'Histoire Naturelle, Paris, France · 2 - Sezione di Scienze Preistoriche e Antropologiche, Dipartimento Studi Umanistici, Università degli Studi di Ferrara, Italy · 3 - Faculty of Archaeology, University of Warsaw, Warszawa, Poland · 4 - Department of Environmental Biology, Sapienza University of Roma, Italy · 5 - Department of the Earth and environmental sciences, University of Bari Aldo Moro, Italy · 6 - Department of Anthropology, Kenyon college, Ohio, USA · 7 - Department of Geosciences, Section of Terrestrial Palaeoclimatology, Eberhard-Karls-University Tübingen · 8 - Department of sciences of antiquity, University of Roma-Sapienza, Italy · 9 - Department of Environmental Biology, Sapienza University of Roma, Italy · 10 - Dipartimento di Biologia Ambientale, Sapienza Università di Roma, Rome, Italy · 11 - Department of Environmental Biology, Sapienza University of Roma, Italy · 12 - Laboratoire des Sciences du Climat et de l'Environnement, CEA-Orme des Merisiers, Université Paris-Saclay, Gif sur Yvette, France · 13 - Laboratoire GEOPS, Université Paris-Saclay, Orsay, France · 14 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain · 15 - National Natural History Collections, Institute of Earth Sciences, Institute of Archaeology, Jerusalem, Israel · 16 - CR2P, UMR 7207, Centre de recherche en paléontologie, Université de Jussieu, Paris · 17 - Dipartimento di Biologia Ambientale, Sapienza Università di Roma, Rome, Italy

The site of Notarchirico (Southern Italy) yields a long sequence dated between 700 and 600 ka with more than 10 phases of human occupation. Extended excavations were performed in the past on the upper part of the sequence by M. Piperno's team. New excavations are undergone for 10 years focusing on the bottom of the sequence. <sup>40</sup>Ar/<sup>39</sup>Ar dating on pyroclastic minerals originated from the Monte Vulture volcano as well as ESR dating on quartz have permitted to clearly delimit a time window of a key phase for understanding the onset of new behaviours in Western Europe, including the Acheulean linked to the introduction of bifaces. As part of the interdisciplinary program ERC LATEUROPE, the new revision of the faunal and lithic assemblages, as well as the femoral shaft attributed to a young adult *H. heidelbergensis*, representing the oldest human fossil specimen from the Italian Peninsula, allowed us to provide a new overview on the recurrent hominin presence. A wide range of herbivores and carnivores have been discovered, including proboscideans, cervids, bovids, rhinoceros, hippopotami, felids, mustelids, suids, rodents, lagomorphs, and insectivores. Extended analyses of the faunal assemblages revealed phases in the Italian biostratigraphy such as two interglacial (MIS 17-15) and one glacial (MIS 16) stages. One worth noticing result concerns a remain of *Panthera spelaea* dated around 650 ka. It constitutes the oldest remain of a Lion discovered so far. Direct association between faunal remains and the presence/use of artefacts are not certain so far, even in the Elephant area (level A-A1). Ongoing isotopic analyses will provide in the near future more paleoenvironmental data related to human occupations. Due to the state of preservation of the bone's surfaces, it is difficult to observe modification either by human or/and carnivores.

The presence of lithic tools is constant along the whole sequence, although they vary in quantities and raw material types (cherts, radiolarite and other stones). The techno-economic approach was used to identify what happened on the site from raw material selection to knapping and shaping, and to contribute to identifying hominin strategies. Some shifts or gradual changes in technology, toolkit or raw material selection are visible over time; other trends seem to persist throughout the whole sequence and hypotheses about possible adaptation of hominins to the climatic changes in the South of Europe are explored. The debitage mainly occurs in situ on small nodules of cherts and radiolarites while the heavy-duty tools, including bifaces, are mainly shaped on various stones. Core technologies are often basic strategies, adapted mostly to the small nodules. Some of the smallest nodules are retouched, composing the light-duty tool kit with tiny flakes and flake-tools. Bifaces are rare and are not recorded in some levels. When present, bifaces are mostly minimally-shaped and present a large diversity of forms. The detailed identification of the raw materials attests to a local selection by hominins of some categories of stones according to the quality, shapes and sizes, and perhaps also depending on their availability. The technological study was coupled with the use-wear analyses, which provides information on a wide range of activities and actions. The site is therefore unique, with a long sequence of about 100 ka documenting recurrent human presence in a lacustrine environment, in competition with carnivores, on a place with abundant raw materials and carcasses of large herbivores. Some groups mastered the biface production, representing one of the earliest Acheulean evidence in Western Europe.

References: [1] Moncel, M.-H., Santagata, C., Pereira, A., Nomade, S., Voinchet, P., Bahain, J.-J., Daujeard, C., Curci, A., Lemerini, C., Hardy, B., Eramo, G., Berto, C., Raynal, J.-P., Arzarello, M., Mecozi, B., Iannucci, A., Sardella, R., Allegretta, I., Delluniversità, E., Terzano, R., Dugas, P., Jouanic, G., Queffelec, A., d'Andrea, A., Valentini, R., Minucci, E., Carpentiero, L., Piperno, M., 2020. The origin of early Acheulean expansion in Europe 700 ka ago: new findings at Notarchirico (Italy). *Scientific Reports*. 10. [2] Pineda, A., Mecozi, B., Iannucci, A., Carpentieri, M., Sardella, R., Rabinovich, R., Moncel, M.-H., 2024. Reevaluating the “elephant butchery area” at the Middle Pleistocene site of Notarchirico (MIS 16) (Venosa Basin, Basilicata, Italy). *Quaternary Science Reviews*. 331, 108603. [3] Micarelli, I., Minozzi, S., Rodriguez, L., di Vincenzo, F., García-González, R., Giuffra, V., Paine, R.R., Carretero, J.-M., Fornaciari, G., Moncel, M.-H., Manzi, G., 2024. The oldest fossil hominin from Italy: Reassessment of the femoral diaphysis from Venosa-Notarchirico in its Acheulean context. *Quaternary Science Reviews*. 334, 108709. [4] Iannucci, A., Mecozi, B., Pineda, A., Sardella, R., Carpentieri, M., Rabinovich, R., Moncel, M., 2024. Early occurrence of lion (*Panthera spelaea*) at the Middle Pleistocene Acheulean site of Notarchirico (MIS 16, Italy). *Journal of Quaternary Science*. 39, 683–690. [5] Mecozi, B., Iannucci, A., Carpentieri, M., Pineda, A., Rabinovich, R., Sardella, R., Moncel, M.-H., 2024. Climatic and environmental changes of ~100 thousand years: The mammals from the early Middle Pleistocene sequence of Notarchirico (southern Italy). *PLOS ONE*. 19, e0311623.

Podium Presentation, Session 1, Thursday 09:20 – 11:00

## First geometric morphometric study of the four Arago mandibles: implications for Middle Pleistocene hominin evolution

Aurélien Mounier<sup>1,2,3</sup>, Tony Chevalier<sup>1,4</sup>, Thomas Colard<sup>5,6</sup>, Christian Perrenoud<sup>1,4</sup>, Marie-Antoinette de Lumley<sup>1</sup>

1. Histoire Naturelle des Humanités Préhistoriques (HNHP, UMR 7194), PaleoFED/PAST, MNHN/CNRS/UPVD, Musée de l'Homme, Paris, France · 2. Turkana Basin Institute, Nairobi, Kenya · 3. CNRS, UAR 3129 – UMIFRE 11 3 Maison Française d'Oxford, Oxford, UK · 4. Centre Européen de Recherches en Préhistoire de Tautavel, Tautavel, France · 5. Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, F-33600 Pessac, France · 6. Department of Oral and Maxillofacial Radiology, Univ. Lille, Lille University Hospital, Lille, France

The Caune de l'Arago (Pyrénées-Orientales, France) has been the focus of archaeological work for over 60 years. From 1964, a large excavation inside the cave was opened which would ultimately lead to the discovery of 152 human remains to date. The Arago hominin fossils represent a minimum of 32 individuals, and have been dated between ~560 ka and ~360 ka, making them the oldest hominin remains in France, and the cave, one of the most important sites for the study of European Middle Pleistocene hominin evolution. Among the hominin fossils, six mandibles were found, of which four are in a very good state of preservation. Arago 2, 13, 89 and 119/130 were discovered in layers G and F of the cave which have been dated to ~450 ka. The mandibles, along with the other hominin remains, have recently been thoroughly described in a monograph [1]. The present study aims at complementing this work by studying the four mandibles using up to date geometric morphometric approaches.

We collected 251 landmarks and semi-landmarks from the whole morphology of 67 mandibular specimens (i.e., 32 *Homo sapiens*, 14 *Homo neanderthalensis*, 6 *Homo erectus s.l.*, 11 Middle Pleistocene individuals and the four Arago mandibles). Missing landmarks were estimated by mirroring and Thin-Plate Spline (TPS) interpolation. The right and left hemi-mandibles landmarks configurations were then aligned using general Procrustes analysis (GPA) and the rest of the study was led on the mean right and left shape of the specimens (i.e. 131 landmarks per specimen). The database was separated into two different matrices, one comprising the full mandibular shape and one focusing on the morphology of the mandibular corpus (i.e. 80 landmarks), which were analysed separately using PCA, to explore the morphological variation within our sample, and Multinomial Component Logistic Regression (MLR) models to estimate the morphological affinities of the specimen of our study group [2].

Our main results indicate that the Arago specimens form a coherent group in terms of mandibular shape variability and show little variation in the morphospaces. They show the strongest shape affinities with other European Middle Pleistocene specimens, such as Mauer and Montmaurin along with one individual from the Sima de los Huesos comparative sample. The shape of the Arago mandibles, and contrary to most of the Sima de los Huesos sample, is on average quite distinct from the *Homo neanderthalensis* sample analysed in the present study.

The Arago mandibular sample appears to be representing a fossil population that was distinct from *Homo neanderthalensis* and that could be named *Homo heidelbergensis* given the strong phenetic affinity that they share with the Mauer mandible, holotype of the species. We further discuss the evolutionary significance of the Arago sample and of *Homo heidelbergensis* with regard to the phenetic affinities between Arago and other important Middle Pleistocene specimens, including specimens from the Sima de los Huesos, Tighenif (African Middle Pleistocene hominins) and Xiahe (possible Denisovan specimen from Late Middle Pleistocene Tibet [3]).

References: [1] de Lumley, M.-A. (Ed.), 2022. Les Restes Humains Du Pléistocène Moyen de La Caune de L'Arago (CNRS Editions) vol. IX of Caune de l'Arago, Tautavel-en-Rousillon Pyrénées-Orientales, France. [2] Hautavoinc, H., Arnaud, J., Balzeau, A., Mounier, A., 2024. Quantifying hominin morphological diversity at the end of the middle Pleistocene: Implications for the origin of *Homo sapiens*. *American Journal of Biological Anthropology*. 184, e24915. [3] Chen, F., Welker, F., Shen, C.-C., Bailey, S.E., Bergmann, I., Davis, S., Xia, H., Wang, H., Fischer, R., Freidline, S.E., Yu, T.-L., Skinner, M.M., Stelzer, S., Dong, G., Fu, Q., Dong, G., Wang, J., Zhang, D., Hublin, J.-J., 2019. A late Middle Pleistocene Denisovan mandible from the Tibetan Plateau. *Nature*. 569, 409–412.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## Exploring the underpinnings of endocranial globularity in present-day humans: the role of the lateral ventricles

Sélim Natahi<sup>1,2</sup>, Jean-Jacques Hublin<sup>2,3</sup>, Philipp Gunz<sup>1</sup>

1 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 2 - Chaire de Paléoanthropologie, CIRB, Collège de France, Université PSL, CNRS, INSERM, Paris, France · 3 - Max Planck Institute for Evolutionary Anthropology, 04103 Leipzig, Germany

The braincase of *Homo sapiens* displays a distinctive globular shape characterized by parietal protrusion and cerebellar fossae enlargement, differentiating it from extinct and extant relatives. Studies of fossil crania reveal that the globular shape of the braincase and the endocranial shape emerged throughout the Mid- to Late Pleistocene [1], and may reflect an interplay of evolutionary and developmental changes to the underlying neural organization, alongside changes in facial size and orientation, as well as changes in bone thickness [1-3]. Previous research has demonstrated that Neandertal-introgressed genetic variants offer insights into the genetic basis of endocranial globularity in present-day humans, highlighting differences in neurogenesis within the basal ganglia and cerebellar myelination [4]. More recently, a large-scale genome-wide association study identified the ventricular system as another potential contributor to endocranial shape variation among present-day humans [5]. To explore this link further, we tested whether the volume of the lateral ventricles correlates statistically with endocranial shape using an independent dataset. Specifically, we analyzed MRI scans from 1,075 young adults (22-35 years of age) from the Human Connectome Project (HCP). Focusing exclusively on young adults was essential to avoid confounding effects of age-related neurodegeneration, which substantially alters cerebrospinal fluid (CSF) and ventricular volumes during senescence.

Cortical parcellation and morphometric measurements were obtained directly from the HCP dataset, whereas skull segmentation was performed using a specialized SimNIBS 4.5 pipeline. We digitized a dense set of landmarks and semilandmarks on the MNI152 brain template, which were transferred onto each individual's MRI via volumetric non-linear deformation fields. After optimizing semilandmark positions through sliding, we computed Procrustes shape coordinates for geometric morphometric analyses. We used multivariate regression to determine how the volume of the lateral ventricles affects overall endocranial shape. This revealed a statistically significant association ( $p < 0.001$ , permutation test) between the volume of the lateral ventricles and key features of endocranial globularity, including parietal bulging and anterior-posterior elongation.

Our findings confirm the hypothesized link between the ventricular system and endocranial globularity. Nevertheless, although statistically significant, this relationship accounts for only a modest fraction of overall endocranial shape variance among present-day humans. Our results therefore point to a complex interplay between CSF dynamics, ventricular morphology and size, and endocranial shape. Further developmental studies are necessary to clearly distinguish causative mechanisms. The small proportion of explained shape variance indicates that the ventricular system alone is unlikely to fully explain the evolutionary changes in endocranial shape observed within the *Homo sapiens* lineage.

References: [1] Neubauer, S., Hublin, J.-J., Gunz, P., 2018. The evolution of modern human brain shape. *Science Advances*. 4. [2] Zollikofer, C.P.E., Bienvenu, T., Ponce de León, M.S., 2016. Effects of cranial integration on hominid endocranial shape. *Journal of Anatomy*. 230, 85–105. [3] Natahi, S., Neubauer, S., Tsegai, Z.J., Hublin, J.-J., Gunz, P., 2025. Cranial vault thickness, its internal organization, and its relationship with endocranial shape in Neanderthals and modern humans. *Journal of Human Evolution*. 204, 103683. [4] Gunz, P., Tilot, A.K., Wittfeld, K., Teumer, A., Shapland, C.Y., van Erp, T.G.M., Dannemann, M., Vernot, B., Neubauer, S., Guadalupe, T., Fernández, G., Brunner, H.G., Enard, W., Fallon, J., Hosten, N., Völker, U., Profico, A., Di Vincenzo, F., Manzi, G., Kelso, J., St. Pourcain, B., Hublin, J.-J., Franke, B., Pääbo, S., Macciardi, F., Grabe, H.J., Fisher, S.E., 2019. Neandertal introgression sheds light on modern human endocranial globularity. *Current Biology*. 29, 120-127.e5. [5] Molz, B., Eising, E., Alagöz, G., Schijven, D., Francks, C., Gunz, P., Fisher, S.E., 2024. Imaging genomics reveals genetic architecture of the globular human braincase.

Poster Presentation Number 108, Session 2, Friday 14:00 - 15:30

## A reinvestigation of the Upper Paleolithic postcranial human remains from the La Rochette rock shelter (Saint-Léon-sur-Vézère, France)

David Naumann<sup>1</sup>, Katerina Harvati<sup>1,2,3</sup>

1 - Paleoanthropology, Institute for Archaeological Sciences, Department of Geosciences, Eberhard Karls University of Tübingen, Tübingen, Germany · 2 - Senckenberg Centre for Human Evolution and Palaeoenvironment, Eberhard Karls University of Tübingen, Tübingen, Germany · 3 - DFG Center for Advanced Studies 'Words, Bones, Genes, Tools: Tracking Linguistic, Cultural and Biological Trajectories of the Human Past', Eberhard Karls University of Tübingen, Tübingen, Germany

The rock-shelter of La Rochette is one of the lesser-known Paleolithic sites in the famous Vézère river valley in southwestern France. Pleistocene deposits at the site contained Upper Paleolithic adult postcranial human remains found during the first archaeological excavations led by O. Hauser in 1910 [1]. The first morphological descriptions were published in 1914 [2], but since then, no additional work has been done on the anatomy of La Rochette's human remains. Here, we present the first comprehensive reinvestigation, including a review of the site history and the previous research on these skeletal remains, as well as new data on osteometry, the association of skeletal elements, and estimations of body proportions and body size.

As the current location of the humeri and femora is unknown, the original anatomy was only possible to study for the radius and ulna; casts were used to collect data for the humeri and femora. To assess the reliability of casts for the study of Pleistocene remains, we compared data from the original radius and ulna to equivalent measurements obtained from their casts. We show that the casts are affected by slight to modest deformation and that, while some linear distances are similar, others show substantial deviations. Furthermore, the virtual superimpositions of 3D surface models and the meshDist models of casts and originals showed that the casts reproduced the originals unevenly, with some areas shaped slightly disproportionately or showing differences in curvatures.

The association of skeletal elements was assessed qualitatively for the right humerus, radius, and ulna based on the morphology of the joint articulations. General similarities in the appearance, robusticity, and the accuracy of fit of the joint articulations were used for this assessment. The examinations of associations of skeletal elements indicate that the right humerus, radius, and ulna very likely belonged to the same individual. Although the upper limb overall size and morphology is consistent with that of the femora, suggesting that all remains may indeed represent one individual, an assessment of the association of the upper and lower limbs was impossible. Therefore, the presence of another adult individual at the site cannot not be excluded at present.

Comparisons of measurements obtained from the original La Rochette radius and ulna with other Upper Paleolithic individuals placed these skeletal elements at the region of overlap of males and females. Similarly, body mass and stature estimates calculated based on measurements from the right femoral cast also fell in this range and within the variation of Upper Paleolithic females. Even though La Rochette's small skeletal proportions might create an impression of gracility, examinations on the skeletal bone robusticity found overall well-developed muscle markings that indicate intense physical activities influenced the skeletal morphology. This is also indicated by the strong asymmetry found between the left and right humerus casts.

This research was supported by ERC AdG 101019659 'FIRSTSTEPS'

References: [1] Delporte, H., 1962. Le gisement paléolithique de La Rochette (commune de Saint-Léon-sur-Vézère, Dordogne). *Gallia préhistoire*. 5, 1 – 22. [2] Klaatsch, H., Lustig, W., 1914. Morphologie der paläolithischen Skelettreste des mittleren Aurignaciens der Grotte von La Rochette, Dep. Dordogne. *Archiv Für Anthropologie, Organ Der Deutschen Gesellschaft Für Anthropologie, Ethnologie Und Urgeschichte*. N. F. Bd. XIII. (Der ganzen Reihe Band XLI.), 80 – 126.

Poster Presentation Number 109, Session 2, Friday 14:00 - 15:30

## Deep evolutionary splits in Middle Pleistocene *Homo* linked to multidirectional dispersals

Xijun Ni<sup>1,2,3</sup>, Pianpian Wei<sup>3</sup>, Chi Zhang<sup>1,2</sup>, Chris Stringer<sup>4</sup>

1 - Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China · 2 - College of Earth and Planetary Sciences, University of Chinese Academy of Sciences, Beijing, China · 3 - PaleoAnthropological Research Center, Fudan University, Shanghai, China · 4 - Centre for Human Evolution Research, Natural History Museum, London, UK

Phylogenetic reconstruction is essential for understanding evolutionary dynamics, especially the complex diversification patterns within our genus, *Homo*. In this study, we present a comprehensive reassessment of *Homo* phylogeny by compiling and analyzing an extensively revised morphological dataset. Our dataset includes a wide range of Pleistocene *Homo* fossils from Africa, Asia, and Europe, an updated character matrix that incorporates traditional craniodental metrics and discrete characters, and chronological data that has been critically evaluated based on recent geochronological and biostratigraphic studies. We employ a dual analytical approach to maximize phylogenetic resolution and temporal inference. First, we conduct parsimony-based phylogenetic analyses using unweighted morphological characters to establish robust topological relationships. Second, we use Bayesian tip-dating methods to simultaneously estimate phylogenetic relationships and divergence times, accounting for morphological evolution and fossil age uncertainties. Our analyses focus on resolving the phylogenetic positions of key yet enigmatic taxa, such as *H. longi* (Dragon Man), *H. naledi*, and *H. floresiensis*, as well as important fossil populations, including Xujiayao, Penghu, Xuchang, Xiahe, and genetically identified Denisovans.

Our results reveal deep phylogenetic divergence among the *H. neanderthalensis*, *H. sapiens*, and *H. longi* clades, with estimated divergence times exceeding one million years. These estimates align with genomic inferences and support the idea of early cladogenesis in *Homo*. This suggests that *Homo* speciation is more complex than previously recognized. Our study provides robust morphological evidence for a cohesive *H. longi* clade, which includes the Harbin cranium, the Xiahe mandible, the Xuchang cranial remains, the Penghu fossils, and the Denisovans. This clade consistently emerges as the sister group to *H. sapiens* in all analyses. Through the integration of phylogenetic and paleobiogeographic data, we reconstruct a scenario of multidirectional hominin dispersals during the Middle Pleistocene. This scenario emphasizes the complex biogeographic relationships between African, Asian, and European *Homo* species/populations.

Recognizing the *H. longi* clade as a major Asian sister group to *H. sapiens* necessitates reconsidering traditional models of human origins. Our reconstructed dispersal patterns challenge simple, unidirectional models of *Homo* dispersal. Instead, they support a dynamic scenario of repeated population movements and interactions across the Old World during the Middle to Late Pleistocene.

Podium Presentation, Session 1, Thursday 09:20 – 11:00

## The secret lives of Paleolithic teens: assessing puberty status in a sample of European Upper Paleolithic adolescents

April Nowell<sup>1</sup>, Mary E. Lewis<sup>2</sup>, Jennifer C. French<sup>3</sup>, Elena Rossoni-Notter<sup>4</sup>, Olivier Notter<sup>4</sup>, Abdelkader Moussous<sup>4</sup>, Francesco Boschini<sup>5</sup>, Stefano Ricci<sup>5</sup>

1 - University of Victoria · 2 - University of Reading · 3 - University of Liverpool · 4 - Museum of Prehistoric Anthropology of Monaco · 5 - University of Siena

Childhood and adolescence are two life-history stages that are either unique to humans, or significantly expanded in the human life course relative to other primates. While recent studies have deepened our knowledge of childhood in the Upper Paleolithic, adolescence in this period remains understudied. Adolescence is marked by intensive biological, cognitive and psycho-social changes and by studying adolescents, there is an enormous potential for understanding Upper Paleolithic lifeways more broadly. In this presentation, we address one gap in our knowledge of Upper Paleolithic adolescence—puberty.

Here, we use bioarchaeological maturational markers to estimate puberty status of 13 Upper Paleolithic adolescents from sites in Russia, Czechia, and Italy to 1) evaluate the feasibility of the application of bioarchaeological puberty assessment methods to Upper Paleolithic (*Homo sapiens*) skeletal individuals, 2) estimate the timing and tempo of puberty in this population and 3) Characterize adolescence in the UP by contextualizing the results of this puberty assessment with data on individual and population level health and morbidity and burial practices. Although variable, our results revealed that puberty had begun between 10-13.5 years of age. Assessing the age of menarche was difficult due to the paucity of female adolescents, but based on the available evidence, it appears to have occurred between 16 and 17 years of age. Full adulthood was achieved by most individuals in our sample by 17-22 years, similar to the patterns seen in modern wealthy countries and in advance of historic populations living in urbanized environments.

To illustrate how puberty assessments in combination with archaeological evidence represent an unparalleled means of reconstructing identity in the past, we present osteobiographies of 2 individuals, Arene Candide 1 and Romito 2. We conclude that the bioarchaeological analysis of puberty among Upper Paleolithic adolescents has important implications for the study of the emergence of adolescence within human-life histories, as well as for understanding the developmental plasticity of sexual maturation across past and present human populations.

We thank Daniela Costanzo (Museo Archeologico Nazionale di Reggio Calabria) and Sandra Sazelova (Czech Academy of Sciences, Institute of Archeology at Brno, Center for Paleolithic and Paleoanthropology) for facilitating our access to the Romito 2 and Dolní Vestonice collections, respectively; the Prince's Palace of Monaco and the Department of Cultural Affairs of Monaco for allowing us access to the Grotte dei Fanciulli collection; Prof. Annamaria Ronchitelli (University of Siena) and the Soprintendenza Archeologia, Belle Arti e Paesaggio per le Province di Barletta-Andria-Trani e Foggia for making the study of the Paglicci 12 burial possible; Libby Cowgill and Erik Trinkaus, for sharing data, images, and radiographs on the Barma Grande and Sungir specimens, respectively; Joanna Moore, Janet Montgomery, and Nicolas Stewert (AIPRI,

University of Durham) for peptide analysis; and Kirsten Blomdal and Robert Gustas for research assistance. This work was funded by the Social Science and Humanities Research Council of Canada and University of Victoria.

References: [1] Lewis, M.E., French, J.C., Rossoni-Notter, E., Notter, O., Moussous, A., Sparacello, V., Boschini, F., Ricci, S., Nowell, A., 2025. An assessment of puberty status in adolescents from the European Upper Paleolithic. *Journal of Human Evolution*. 198, 103577. [2] Lewis, M., Shapland, F., Watts, R., 2015. On the threshold of adulthood: A new approach for the use of maturation indicators to assess puberty in adolescents from medieval England. *American Journal of Human Biology*. 28, 48–56. [3] Nowell, A., French, J.C., 2020. Adolescence and innovation in the European Upper Paleolithic. *Evolutionary Human Sciences*. 2. [4] French, J.C., Nowell, A., 2022. Growing up Gravettian: Bioarchaeological perspectives on adolescence in the European Mid-Upper Paleolithic. *Journal of Anthropological Archaeology*. 67, 101430. [5] Stewart, N.A., Gerlach, R.F., Gowland, R.L., Gron, K.J., Montgomery, J., 2017. Sex determination of human remains from peptides in tooth enamel. *Proceedings of the National Academy of Sciences*. 114, 13649–13654.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## Revisiting femoral anteversion in Hominoids: a new approach using 3D data

Zoé Nowicki<sup>1</sup>, Franck Guy<sup>1</sup>, Amélie Beaudet<sup>1</sup>, Alicia Blasi-Toccaceli<sup>1,2</sup>, Laurent Pallas<sup>1,3</sup>, Jérôme Surault<sup>1</sup>, Guillaume Daver<sup>1</sup>

1 - Laboratoire de Paléontologie, Evolution, Paléoécosystèmes et Paléoprimatologie (PALEVOPRIM), Université de Poitiers, CNRS, Poitiers, France · 2 - Department of Anatomy, Midwestern University, AZ, USA · 3 - Histoire Naturelle de l'Homme Préhistorique (HNHP), CNRS-MNHN-UPVD, Musée de l'Homme, Paris, France

While non-human primates are able to stand and move bipedally, only humans and their closest fossil relatives demonstrate the ability for long-distance walking and endurance running. Notably, hominin hindlimbs exhibit a suite of morphological features associated with this locomotor behaviour, which reflect resistance to various mechanical stresses. Among the morpho-functional traits suggested to be related to bipedal locomotion, femoral anteversion has been proposed as a potential marker [1], but the relevance of this trait has been questioned [2]. Despite being widely studied in extant humans (particularly in medical science), this trait remains surprisingly understudied in both extant and extinct hominoids [3]. Moreover, methods for characterizing femoral anteversion vary considerably across studies. We hypothesise that classical 2D methods—including the femoral head in defining the neck axis—introduce unwanted variation in anteversion measurements. Here we propose a new method that intends to overcome these challenges. Our study question whether measurement of the anteversion, that relies on a definition that includes or excludes the head, are indeed comparable, and whether this anteversion is related to bipedalism.

In this perspective, we analysed 3D meshes of 123 extant femora, comprising 38 modern humans, 37 *Pan*, 21 *Gorilla*, 14 *Pongo*, and 13 Hylobatids. To standardize femoral alignment, we defined both a diaphyseal axis and a condylar axis. We then revised the original method for quantifying femoral anteversion proposed by Martin and Saller [4] for applications to 3D meshes. To evaluate the relevance of excluding the femoral head in anteversion measurements, we compared two methods based on different definitions of the femoral neck axis. The first method defines the neck axis using the centre of the femoral head (considered as a sphere) and a single cross-section of the neck. The second method defines the neck axis using two cross-sections of the femoral neck, thus excluding the head from the measurement.

Firstly, our results show that the orientation of the femoral head relative to the femoral neck significantly affects quantification of anteversion, except in humans. This may reflect the integrative nature of the femoral neck and head in humans, suggesting possible functional constraints on the morphology of the proximal epiphysis. Secondly, the inclusion of the femoral head in the definition of the neck axis does not allow to distinguish humans (mean=19.54°, SD=11.21°) from other hominoids, except for *Gorilla* (mean=10.69°, SD=7.33°) and *Pongo* (mean=4.52°, SD=12.37°). No significant difference is observed between *Homo*, *Pan* (mean=12.88°, SD=6.77°), and hylobatids (mean=17.24°, SD=8.99°). In contrast, excluding the femoral head helps with clearly distinguishing humans (mean=20.59°, SD=10.54°) from all other taxa (*Pan*: mean=5.81°, SD=8.96°; *Gorilla*: mean=4.39°, SD=7.91°; *Pongo*: mean=1.95°, SD=15.53°; hylobatids: mean=9.09°, SD=10.45°). These results indicate that the femoral head appears to be anteriorly oriented in hominoids compared to the neck axis, except in humans.

These findings suggest that: (1) femoral anteversion—based on the neck only—may serve as a reliable marker of bipedalism in humans, alongside the ventral orientation of the acetabulum [5]; and (2) there may be a complex interaction between femoral head orientation and acetabular positioning in other hominoids. This research provides new insights into the evolution of form-function relationships related to locomotion in hominoids, especially to bipedalism in hominins. However, as fossil femora are often poorly preserved, we are currently working on identifying suitable proxies for estimating femoral anteversion in the fossil record.

I thank the curators and staff who granted access to the osteological collections of the following institutions: the Royal Museum for Central Africa (E. Gillissen, W. Coudyzer); the Museum für Naturkunde, Berlin (C. Funk); the National Museum of Natural History, Smithsonian Institution; the American Museum of Natural History (N. Duncan); the Forensic Analysis Laboratory, North Carolina State University (R. Cook); the Museum of Comparative Zoology, Harvard University (M. Omura); the Musée de l'Homme, Paris (M. Friess, V. Labordes, A. Fort, L. Huet) and the Université de Poitiers. This project has received financial support from the Région Nouvelle Aquitaine (AH-HEM & COVAROS, AAPR 2024A-2024-32945810), the CNRS through the MITI interdisciplinary program "Jumeaux Numériques", the International Research Network "Bipedal equilibrium" (CNRS-INEE GDRI0870) and PALEVOPRIM, UMR 7262.

References: [1] Tardieu, C., 2010. Development of the human hind limb and its importance for the evolution of bipedalism. *Evolutionary Anthropology: Issues, News, and Reviews*. 19, 174–186. [2] Lovejoy, C.O., Cohn, M.J., White, T.D., 1999. Morphological analysis of the mammalian postcranium: A developmental perspective. *Proceedings of the National Academy of Sciences*. 96, 13247–13252. [3] Ward, C.V., Walker, A., Teaford, M.F., Odhiambo, I., 1993. Partial skeleton of *Proconsul nyanzae* from Mfangano Island, Kenya. *American Journal of Physical Anthropology*. 90, 77–111. [4] Martin, R., Saller, K., 1957. *Lehrbuch der Anthropologie in systematischer Darstellung. Mit besonderer Berücksichtigung der anthropologischen Methoden*, vol. 1. Gustav Fischer Verlag, Stuttgart. [5] Lawrence, A.B., Hammond, A.S., Ward, C.V., 2025. Acetabular orientation, pelvic shape, and the evolution of hominin bipedality. *Journal of Human Evolution*. 200, 103633.

Poster Presentation Number 110, Session 2, Friday 14:00 - 15:30

## **Fallow deer abundances and age profiles indicate opportunistic hunting in the Middle Paleolithic Levant**

**Meir Orbach<sup>1</sup>, Reuven Yeshurun<sup>1</sup>**

1 - School of Archaeology and Maritime Cultures, Zinman Institute of Archaeology, University of Haifa, Israel

Advanced Paleolithic hunting skills have been suggested to include the targeting of specific prey species or prime-age herd individuals. The Mesopotamian fallow deer (*Dama mesopotamica*) was the second most abundant prey species in Levantine Middle Paleolithic anthropogenic sites, and it has been argued that humans deliberately hunted prime-aged individuals since the late lower Paleolithic. We conducted a regional analysis of the fallow deer relative abundance and age structure at Middle Paleolithic cave sites in the Mediterranean zone of the southern Levant. We also refined and standardized fallow deer dental ageing, responding to critical discrepancies between existing methods regarding the prime/old age boundary that change significantly the interpretation of mortality curves.

Our study demonstrates that using wear diagrams, supplemented by crown height measurements for specific wear stages, enables coherent separation of age cohorts, e.g., more precise definition of prime-adult and old-adult individuals. Following that, our results show that fallow deer are more abundant in natural traps than human sites and hyena dens. Furthermore, the unselective age structure observed across all sites, regardless of how they accumulated, refutes the assertion of intentional fallow deer selection, neither at the species level nor within specific age cohorts. At the same time, species associated with open environments, the smaller-bodied gazelle and much larger aurochs, seem to have been preferentially targeted.

These lines of evidence suggest that Levantine Paleolithic hunters preferred open biomes and captured fallow deer opportunistically as they traveled to their designated hunting grounds. We suggest that this patch-choice pattern may be attributed to the reduced search costs in non-wooded environments and gregarious anti-predatory behaviors of prey species. Ultimately, we demonstrate that animal size was not a primary determinant of human prey choice in the Middle Paleolithic southern Levant.

Poster Presentation Number 111, Session 2, Friday 14:00 - 15:30

## The lower premolars from the Ruidera Middle Pleistocene site (Ciudad Real, Southern Iberian Plateau): a study of the evolution of dentin morphology and enamel density

Sofía Pablo Pozas<sup>1</sup>, Cecilia García-Campos<sup>2</sup>, María Hernáiz-García<sup>2</sup>, Sara Díaz Pérez<sup>3</sup>, Carlos A. Palancar<sup>4</sup>, Daniel García Martínez<sup>1,5</sup>

1 - Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 2 - Laboratorio de Poblaciones del Pasado, Facultad de Ciencias, Universidad Autónoma de Madrid, Madrid, Spain · 3 - Institute of Archaeology, University of Wrocław, Wrocław, Poland · 4 - Grupo de Paleoantropología, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (MNCN - CSIC) · 5 - Laboratory of Forensic Anthropology, Centre for Functional Ecology, Department of Life Sciences, Universidade de Coimbra, Coimbra, Portugal

The study of dentition is crucial for understanding the evolution of *Homo* due to its high interspecific variability, good preservation in the fossil record, and its ability to provide significant insights into behavior and dietary adaptations [1]. This study analyzes three lower human premolars recovered from the Ruidera site, dated to between 300,000 and 400,000 years ago [2], using virtual anthropology techniques, including micro-computed tomography (micro-CT), semi-automatic segmentation, and geometric morphometrics. Quantitative data on morphology and histology were obtained and compared with those of other hominin species through Generalized Procrustes Analysis (GPA) and Principal Component Analysis (PCA) based on previous methods for premolar semilandmarks protocols [3].

Morphologically, we examined features of the enamel-dentine junction (EDJ), including overall shape, crown size and height, symmetry of the fossae, and relative cusp heights—traits that show systematic differences between archaic and modern taxa [4]. Histologically, we measured the volumes and surface areas of the enamel, dentin, and pulp, as well as enamel thickness, a parameter known to provide important phylogenetic insights [5].

Our results reveal a mosaic of archaic and modern traits. The third premolar (p3) exhibits symmetrical fossae and a relatively thin enamel cap, characteristics more closely aligned with modern forms such as *H. neanderthalensis*. In contrast, the fourth premolar (p4) displays low-crowned morphology, symmetrical fossae, and variability in tooth size and enamel thickness, with some specimens resembling archaic species like *H. erectus*, while others are closer to *H. sapiens*.

This mosaic pattern supports two potential hypotheses: (1) the Ruidera specimens represent a common ancestor of both modern humans and Denisovans and Neanderthals; (2) they belong to a pre-Neanderthal and Denisovan population undergoing mosaic evolution. Future excavations and analyses of additional skeletal elements may help clarify the taxonomic relationships of what could be among the earliest inhabitants of the southern Plateau of the Iberian Peninsula.

This research is funded by Leakey Foundation project ID: 45148 (2024-2025) entitled “Paleoanthropological investigation at Ruidera-Los Villares: Deciphering Middle Pleistocene Enigma in Western Europe”; and also, by Fundación PALARQ project entitled “Desvelando la Cronología del Pasado Humano: Análisis Multimétodo de Datación en el Yacimiento de Ruidera-Los Villares, Pleistoceno Medio”. We acknowledge the neighbours and institutions from Ruidera for their hospitality as well as Junta de Comunidades de Castilla-La Mancha and Parque Natural de las Lagunas de Ruidera for awarding the permits for the excavation. We also want to acknowledge the entire excavation team for their great and selfless work.

References: [1] Bailey, S. E., Hublin, J. J. (Eds.). (2007). Dental perspectives on human evolution: state of the art research in dental paleoanthropology. Berlin: Springer. [2] García Martínez, D., Duval, M., Zhao, J., Feng, Y., Wood, R., Huguet, R., Cifuentes-Alcobendas, G., Palancar, C.A., Moya-Maleno, P.R., 2022. Los Villares locality (Ruidera, Castilla-La Mancha, Spain): a new Middle Pleistocene fossil assemblage from the Southern Iberian Plateau with possible evidence of human activity. Cuaternario y Geomorfología. 36, 7–35. [3] Davies, T.W., Gunz, P., Spoor, F., Alemseged, Z., Gidna, A., Hublin, J.-J., Kimbel, W.H., Kullmer, O., Plummer, W.P., Zanolli, C., Skinner, M.M., 2024. Dental morphology in *Homo habilis* and its implications for the evolution of early *Homo*. Nature Communications. 15. [4] Bermúdez de Castro, J.M., Martínez de Pinillos, M., Martín-Francés, L., Modesto-Mata, M., García-Campos, C., Arsuaga, J.L., Martínón-Torres, M., 2021. Dental remains of the Middle Pleistocene hominins from the Sima de los Huesos site (Sierra de Atapuerca, Spain): Maxillary dentition. The Anatomical Record. 307, 2325–2342. [5] García-Campos, C., Modesto-Mata, M., Martínón-Torres, M., Martín-Francés, L., Martínez de Pinillos, M., Arsuaga, J.L., Bermúdez de Castro, J.M., 2021. Similarities and differences in the dental tissue proportions of the deciduous and permanent canines of Early and Middle Pleistocene human populations. Journal of Anatomy. 240, 339–356.

Poster Presentation Number 112, Session 2, Friday 14:00 - 15:30

## The medial cuneiforms from the Middle Pleistocene site of Sima de los Huesos (Atapuerca, Burgos, Spain)

Adrián Pablos<sup>1,2</sup>, Ignacio Martínez<sup>3</sup>, José Miguel Carretero<sup>4,5</sup>, Juan Luis Arsuaga<sup>1,6</sup>

1 - Departamento de Geodinámica, Estratigrafía y Paleontología, Universidad Complutense de Madrid, Madrid, Spain · 2 - Centro Nacional de Investigación sobre la Evolución Humana-CENIEH, Burgos, Spain · 3- Departamento de Ciencias de la Vida, Catedra de Otoacústica Evolutiva y Paleoantropología (HM Hospitales-Universidad de Alcalá), Universidad de Alcalá, Alcalá de Henares, Spain · 4- Dpto. de Ciencias Históricas y Geografía, Laboratorio de Evolución Humana, Universidad de Burgos, Burgos, Spain · 5- Unidad Asociada de I+D+i al CSIC, Vidrio y Materiales del Patrimonio Cultural (VIMPAC), Burgos, Spain · 6- Centro mixto UCM-ISCIII de Investigación sobre Evolución y Comportamiento Humanos, Madrid, Spain

The human foot plays a key role in locomotion and weight distribution. Furthermore, this element is related to body size and can provide valuable information about taxonomic relationships within the human lineage. Prior to Neandertals and anatomically modern humans, the foot bones are very scarce throughout the *Homo* fossil record. Several medial cuneiforms belonging to the genus *Homo* have been recovered before the appearance of Neandertals and anatomically modern humans (e.g. Jinniushan 1, OH8, Omo-Kibish 1, LB1, and those from Dmanisi and *Homo naledi*). However, the exact timing of the emergence of modern cuneiform morphology and its morphological relationship with Neanderthals remains unclear.

At the Middle Pleistocene site of Sima de los Huesos (SH), more than 7,000 human fossil fragments belonging to at least 29 individuals, have been recovered to date. The hominin-bearing layer can be assigned to a period around 430-450 thousand years ago [1,2]. Morphologically, these fossils are believed to represent an ancestral European population that evolved into the Neandertals [1]. Of this sample of human fossils, 15 belong to medial cuneiforms, representing over 35% of the *Homo* fossil record prior to *Homo sapiens* (over 65% if Neandertals are excluded). These 15 fragments correspond to at least 15 elements from nine individuals (six adults and three immatures). Of the adult individuals identified in the sample, three are probably male and one is likely to be a female [3]. Important information relevant to understanding the evolution of the Neanderthal and modern foot can be extracted from the Sima de los Huesos (SH) first cuneiforms due to the evolutionary and morphological relationship between Neanderthals and the Sima de los Huesos hominins [1].

We analyzed 15 metrical variables in the SH human collection of medial cuneiforms. This enabled us to characterize the morphology of these SH tarsals comparing them to Neandertals, Paleolithic *Homo sapiens*, three recent comparative samples, and earlier specimens throughout the entire fossil record of the genus *Homo*. The medial cuneiforms from SH are long, broad and distally high compared to the comparative samples. We identified some characters that are shared by SH hominins and Neandertals that may represent shared derived or autapomorphic traits for this evolutionary line. Most are likely to be related to robusticity. Additionally, we observed some traits in the SH tarsal sample that were even broader than those in Neandertals, and especially than those of recent and fossil *H. sapiens* (e.g.: plantar breadth). A broad medial cuneiform may be an exclusive trait of the SH population different from Neandertals and *H. sapiens*. This could suggest a slightly higher level of gracilization in the medial cuneiforms of Neandertals compared to the SH sample. This is also supported by other anatomical elements of the postcranial skeleton [3].

Although these are only a few characters, in some ways, the first cuneiforms and, consequently, the tarsals are, in some respects, even more robust in SH than in Neanderthals. A similar pattern is observed in the metatarsals and phalanges, particularly in the hallux elements [4]. Trinkaus [5] established that the morphology of the Neanderthal tarsals was similar to that of recent humans in terms of implied locomotor capabilities.

In conclusion, the study of the medial cuneiforms recovered from the Middle Pleistocene site of Sima de los Huesos confirms that this population and Neanderthals are evolutionary sister groups. However, differences in foot, cranium and other postcranial elements enable us to distinguish the SH hominins from Neanderthals.

We are deeply grateful to SH excavation team. We are indebted to many people who have allowed access to some important skeletal collections. This research is funded by Junta de Castilla y León, Fundación Atapuerca, Ministerio de Ciencia, Innovación y Universidades of Spain (Project PID2021-122355NB-C31 funded by MCIN/AEI/10.13039/501100011033/FEDER). AP has been financed by a research grant from Junta de Andalucía, Spain (EMERGIA20\_00403) and by a Ramón y Cajal fellowship RYC2023-045715-I funded by the MCIN/AEI/10.13039/501100011033 and FSE invierte en tu future.

References: [1] Arsuaga, J.L., Martínez, I., Arnold, L.J., Aranburu, A., Gracia-Téllez, A., Sharp, W.D., Quam, R.M., Falguères, C., Pantoja-Pérez, A., Bischoff, J., Poza-Rey, E., Parés, J.M., Carretero, J.M., Demuro, M., Lorenzo, C., Sala, N., Martínón-Torres, M., García, N., Alcázar de Velasco, A., Cuenca-Bescós, G., Gómez-Olivencia, A., Moreno, D., Pablos, A., Shen, C.-C., Rodríguez, L., Ortega, A.I., García, R., Bonmatí, A., Bermúdez de Castro, J.M., Carbonell, E., 2014. Neandertal roots: Cranial and chronological evidence from Sima de los Huesos. *Science* 344, 1358–1363. [2] Demuro, M., Arnold, L.J., Aranburu, A., Sala, N., Arsuaga, J.-L., 2019. New bracketing luminescence ages constrain the Sima de los Huesos hominin fossils (Atapuerca, Spain) to MIS 12. *Journal of Human Evolution* 131, 76-95. [3] Pablos, A., Arsuaga, J.L., 2024. Tarsals from the Sima de los Huesos Middle Pleistocene site (Atapuerca, Burgos, Spain). *The Anatomical Record* 307, 2635-2664. [4] Pablos, A., Arsuaga, J.L., 2024. Metatarsals and foot phalanges from the Sima de los Huesos Middle Pleistocene site (Atapuerca, Burgos, Spain). *The Anatomical Record* 307, 2665-2707. [5] Trinkaus, E., 1975. A functional analysis of the Neanderthal foot. University of Pennsylvania, Pennsylvania.

Poster Presentation Number 113, Session 2, Friday 14:00 - 15:30

## Postcranial skeleton of the Ruidera hominins: anatomical descriptions and taxonomic implications

Carlos A. Palancar<sup>1</sup>, Sara Díaz Pérez<sup>2</sup>, Tomás Torres Medina<sup>1,3</sup>, Markus Bastir<sup>1</sup>, Marta Gómez Recio<sup>1</sup>, Miguel López Cano<sup>1</sup>, Sofía Pablo Pozas<sup>3</sup>, Antonio Rosas<sup>1</sup>, Daniel García Martínez<sup>3,4</sup>

1 - Grupo de Paleoantropología, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (MNCN - CSIC) · 2 - Institute of Archaeology, University of Wrocław, Wrocław, Poland · 3 - Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 4 - Laboratory of Forensic Anthropology, Centre for Functional Ecology, Department of Life Sciences, Universidade de Coimbra, Coimbra, Portugal ·

Ruidera is an archaeo-paleontological site on the Iberian Peninsula, dated to approximately 300–400 kya using a combined ESR–Uranium series approach [1]. During the 2023 and 2024 field campaigns, over 3,000 faunal remains have been recovered. Among them, more than 50 belong to hominin individuals, including dental, cranial, and postcranial fragments. Within the postcranial assemblage, we have identified nine hand bones, five ribs, three foot phalanges, two vertebrae, one scapula, one humerus, one femur, and one ulna. Although most of these remains are fragmentary—except for the hand and foot elements—preliminary analyses have been conducted on the majority of the postcranial specimens recovered to date.

**Hand remains.** The hand is the anatomical unit with the greatest number of bones recovered so far. Two proximal, two intermediate, and two distal phalanges have been identified, along with two metacarpals and one scaphoid. Based on preliminary analyses, the phalanges' morphology does not differ significantly from that of Neanderthals or modern humans. The metacarpal head-to-body ratio is comparable to that observed in Neanderthals and ATD6 individuals. The scaphoid, however, tells a different story: 3D geometric morphometric (3DGM) analyses of this bone reveal a marked degree of archaicity, showing closer affinities to more ancient species than to Neanderthals or modern humans.

**Foot remains.** One proximal phalanx and two intermediate phalanges comprise the foot remains. Among them, no clear evidence of archaicity or modernity have been detected, and within the analyzed sample, one phalanx from Denisova Cave (Altai) shows the closest morphological similarity [2].

**Vertebrae.** Two cervical vertebrae fragments were recovered and one could be analyzed. Although that fragment only preserved the left superior articular facet and a portion of the lamina, we could analyze the orientation of the facet relative to the lamina. Results show that the orientation is more coronal than in Neanderthals and modern humans, and similar to earlier *Homo* individuals, such as *Homo antecessor*.

**Scapula.** A partial right adult scapula has been analyzed via 3DGM. Compared to *Homo ergaster*, *H. antecessor*, modern humans and Neanderthals, the glenoid fossa from Ruidera presents an intermediate morphology, with the scapula from ATD6 being the closest in terms of morphology.

**Ribs.** Five rib fragments have been identified, though all are incomplete. Despite their fragmentary nature, preliminary observations indicate an exceptionally high degree of mineralization. This level of mineral density falls within the range documented for *Homo erectus*, suggesting biological traits consistent with more archaic hominins.

**Conclusions.** These preliminary findings highlight the significance of the Ruidera site, which provides a unique window into Middle Pleistocene hominin anatomy on the Iberian Peninsula, revealing a mosaic of morphological traits. While certain postcranial elements, such as the hand phalanges, resemble those of Neanderthals and modern humans, others—including the scaphoid, vertebra, scapula, and ribs—exhibit archaic features more typical of earlier hominins such as *H. erectus* or *H. antecessor*. Together, these findings suggest that the Ruidera hominins may represent a population with a distinctive anatomical profile, combining both derived and primitive traits, with important implications for our understanding of hominin diversity and evolution in Western Europe during the Middle Pleistocene.

This research is funded by Leakey Foundation project ID: 45148 (2024-2025) entitled “Paleoanthropological investigation at Ruidera-Los Villares: Deciphering Middle Pleistocene Enigma in Western Europe”; and also by Fundación PALARQ project entitled “Desvelando la Cronología del Pasado Humano: Análisis Multimétodo de Datación en el Yacimiento de Ruidera-Los Villares, Pleistoceno Medio”. We acknowledge the neighbours and institutions from Ruidera for their hospitality as well as Junta de Comunidades de Castilla-La Mancha and Parque Natural de las Lagunas de Ruidera for awarding the permits for the excavation. We also want to acknowledge the entire excavation team for their great and selfless work. MB and AR are funded by the Spanish Ministry of Science and Innovation (PID-2020-115854GB-I00 and PID2021-122356NB-I00).

References: [1] García Martínez, D., Duval, M., Zhao, J., Feng, Y., Wood, R., Huguet, R., Cifuentes-Alcobendas, G., Palancar, C.A., Moya-Maleno, P.R., 2022. Los Villares locality (Ruidera, Castilla-La Mancha, Spain): a new Middle Pleistocene fossil assemblage from the Southern Iberian Plateau with possible evidence of human activity. *Cuaternario y Geomorfología*. 36, 7-35. [2] Mednikova, M.B., 2011. A proximal pedal phalanx of a Paleolithic hominin from Denisova cave, Altai. *Archaeology, Ethnology and Anthropology of Eurasia*. 39, 129-138.

Poster Presentation Number 114, Session 2, Friday 14:00 - 15:30

## Taxonomic and functional signal of the cross-sectional shape of the humerus and femur of extant cercopithecids

Laurent Pallas<sup>1,2,3</sup>, Quentin Cosnefroy<sup>4</sup>, Guillaume Daver<sup>2</sup>, François Druelle<sup>5</sup>, Masato Nakatsukasa<sup>1</sup>

1 - Kyoto University, Graduate School of Science, Laboratory of Physical Anthropology, Kyoto 606-8502, Japan · 2 - UMR 7262, PALEVOPRIM: Laboratoire de Paléontologie, Évolution, Paléoécosystèmes et Paléoprimatologie, Université de Poitiers, Poitiers, France · 3 - UMR 7194, CNRS, Département Homme & Environnement, Muséum National D'Histoire Naturelle, Musée de L'Homme, Paris, France · 4 - UMR 5199, PACEA - De la Préhistoire à l'Actuel: Culture, Environnement et Anthropologie, Université de Bordeaux, Pessac, France · 5 - UMR 7268, Anthropologie bio-culturelle, Droit, Ethique et Santé, AMU-CNRS-EFS, Marseille, France

Although sharing a quadrupedal morphological bauplan, cercopithecoid monkeys are functionally diverse, with adaptations for quadrupedal walking, climbing, leaping, squatting, and running on arboreal and terrestrial substrates. In spite of this diversity, little is known about the variation in cross-sectional shape of their skeletal anatomy. Cross-sectional shape (CSS) reflects the distribution of cortical bone and is biomechanically linked to bone rigidity against bending loads. CSS is commonly used in locomotor inferences in extant primates and applied to the study of locomotion in fossil taxa. However, the impact of phylogeny and function behind the morphogenesis of CSS is debated, raising the question of their respective contributions and interactions. In this context, the study of CSS in a phylogenetically and functionally diverse clade of organisms, namely the Cercopithecidae, offers a relevant model for investigating this interplay. As a working hypothesis, we expect the cross-sections to track adaptations related to mechanical loads and enthesal developments required for each locomotor and substrate preference. To test this hypothesis, we explored the shape of the humeral and femoral transverse cross-sections of eight cercopithecoid taxa, six papionins and two colobines genera. This sample includes arboreal climbers and leapers (e.g., *Colobus*), arboreal suspensors and leapers (e.g., *Nasalis*) along with terrestrial runners (e.g., *Papio*) and taxa with mixed substrate preferences and eclectic behaviors (e.g., *Macaca*). We used 2D geometric morphometric to quantify cross-sections placed at the proximal metaphysis, mid-diaphysis, and distal metaphysis of each bone. MANOVA combined with LDA demonstrated that the proximal and distal humeral metaphyses are significant taxonomic and locomotor discriminants, while, as a whole, the femur had less discriminative power. We emphasized the peculiar anatomy of *Papio* and *Macaca* long bone cross-sections, as well as the accentuated differences between the humerus of arboreal colobines and that of papionins. We have verified the adaptations of the humeral and femoral diaphyseal shape in relation to cursoriality and leaping, but inferences relating to climbing were not confirmed and appear to be phylogenetically driven as differences between papionins and colobines climbers were observed. Future studies on the kinematics and kinetics of climbing in colobines and papionins should address this question.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## The *Paranthropus* paradox: a reconstruction of African Pleistocene environments and diets to better understand *Paranthropus* anatomy

Lucas Pascarelli<sup>1</sup>, Amanda G. Henry<sup>1</sup>

1 - Faculty of Archaeology, Leiden University

The dietary behaviour of *Paranthropus* remains a topic of contention. Their highly robust cranio-dental anatomy has been interpreted as an adaptation for hard-object feeding, while microwear analyses suggest that such foods were only occasionally consumed [1,2]. Dietary interpretations are further confused by stable carbon isotope analyses that point to divergent diets between the eastern African *P. boisei* and southern African *P. robustus*. Reconstructions of the habitats in which these taxa lived and sourced their food could provide the needed contextual information, but such analyses are either over-generalized and vague, or focused on individual sites.

In this project, I created detailed reconstructions of the types of habitats occupied by both eastern and southern African *Paranthropus*, to explore any differences between the two areas and how available foods might have structured their dietary behaviours. The Pleistocene landscapes were reconstructed by collating fossil faunal assemblage lists from research publications and studying the preferred habitats of the taxa that were identifiable at a species level. By comparing the results for each site and considering taxa with more niche preferences, I was able to compare the environments that *P. robustus* and *P. boisei* lived in and the implications this has on their dietary ecology.

The two regions were generally quite similar. However, in eastern Africa the water biomes were more permanent year-round, as seen in all three of the sites studied. Eastern Africa also has almost double the amount of indications for wooded or forested patches than in South Africa. A connecting faunal channel between the two regions is also made clear, suggesting that sedge and grass consuming herbivores could travel between both regions. Through this work and contextual applications from literature, I suggest that *Paranthropus*'s robust anatomy is the result of adaptations to a diet requiring repetitive chewing of tough sedges and grasses, and the reconstruction helps confirm the hard-food fallback theory [2].

The focus on fauna is a distinct limitation; there is a need for more botanical research to better understand whether *Paranthropus* consumed hard or tough foods. The energetic costs of chewing tougher plants could play into this, so determining the relationship between nutritional plant values that are difficult to chew and seeing how they compare across seasons and biomes is one of the gaps that has been opened with this research.

Therefore, our next phase of research involves a focus on nutritional plant values from South Africa, an in-depth analysis of the diet and subsistence methods employed by *P. robustus*, and the implications this has on hominin dietary evolution studies. This includes statistical explorations of the nutritional and antifeedant properties of modern plants found in different biomes in South Africa that also existed during the Pleistocene. Our main aim of this next project is to further detail the dietary pressures that prompted hominin evolution.

References: [1] Ungar, P.S., Krueger, K.L., Blumenshine, R.J., Njau, J., Scott, R.S., 2012. Dental microwear texture analysis of hominins recovered by the Olduvai landscape paleoanthropology project, 1995–2007. *Journal of Human Evolution*. 63, 429–437. [2] Ungar, P.S., Sponheimer, M., 2011. The diets of early hominins. *Science*. 334, 190–193.

Poster Presentation Number 115, Session 2, Friday 14:00 - 15:30

## Phalangeal curvature in Platyrrhine monkeys and implications for the evolution of human hand morphology

Biren A. Patel<sup>1,2</sup>, Joseph K. Won<sup>3,4,5</sup>, Laura E. Hunter<sup>6</sup>, Caley M. Orr<sup>7,8</sup>

1 - Divisions of Integrative Anatomical Sciences, Department of Medical Education, Keck School of Medicine, University of Southern California, CA, USA · 2 - Human and Evolutionary Biology Section, Department of Biological Sciences, University of Southern California, CA, USA · 3 - PhD Program in Anthropology, Graduate Center of the City University of New York, New York, USA · 4 - New York Consortium in Evolutionary Primatology, New York, USA · 5 - Department of Anthropology, Hunter College of the City University of New York, New York, USA · 6 - Department of Organismal Biology and Anatomy, University of Chicago, IL, USA · 7 - Department of Cell and Developmental Biology, University of Colorado School of Medicine, Aurora, CO, USA · 8 - Department of Anthropology, University of Colorado Denver, CO, USA

Curvature of manual proximal phalanges has long served as a key skeletal correlate for reconstructing locomotor behavior in fossil hominins [1]. Greater curvature as seen in extant apes is typically interpreted as an adaptation for habitual below-branch suspensory behaviors, where flexed grasping postures impose high bending loads on the phalanges. Conversely, flatter phalanges are commonly associated with relying less on suspension and more on terrestrial locomotion, particularly in humans, where it has been linked to bipedalism. An alternative to the latter is the hypothesis that the flattened phalanges of humans represent not just a loss of curvature due to the abandonment of arboreal locomotion, but a derived condition shaped by selection for enhanced manual dexterity and precision manipulation.

To test this hypothesis, we investigated whether flat manual phalanges occur in Platyrrhine monkeys that display diverse positional behaviors including forelimb suspension as well as varying degrees of manual dexterity. Our dataset comprises 3D surface models of the third manual proximal phalanx from 98 adult specimens of 17 Platyrrhine genera. We used a 2D geometric morphometric (2DGM) approach to quantify phalangeal shaft curvature relative to body size, focusing on the central longitudinal shape of the shaft's diaphysis [2]. Semi-landmark data were analyzed using Generalized Procrustes Analysis and principal component analysis to assess variation in curvature shape across taxa.

Our results reveal that medium-sized capuchin monkeys (*Cebus* and *Sapajus*), well-known for their frequent tool use, extractive foraging, and coordinated bimanual activities [3], exhibit the flattest phalanges for their body size among the sampled Platyrrhine monkeys including similar sized taxa like pitheciines (*Pithecia*, *Chiropotes*, *Cacajao*). While the small-bodied callitrichines (e.g., *Callithrix*, *Leontopithecus*, *Saguinus*) also exhibit low curvature, their morphology is likely associated with their specialized claw-like nails and vertical clinging behaviors and not size alone since the similarly-sized squirrel monkey (*Saimiri*) has more curved phalanges. In contrast, relatively large-bodied atelines (*Ateles*, *Brachyteles*, *Lagothrix*) display markedly higher phalangeal curvature, consistent with habitual below-branch suspension and flexed grasping postures.

These findings support the hypothesis that reduced phalangeal curvature can evolve convergently in primates with advanced manipulative repertoires, as seen in both humans and capuchins. Thus, the flattened phalanges of modern humans, as well as those of fossil *Homo*, may not be solely a byproduct of bipedal locomotion but instead reflect selective pressures related to tool use, object manipulation, and precision grip. The morphological convergence between the genus *Homo* and capuchins underscores the importance of manual behaviors—beyond locomotor ecology—in shaping the evolution of digital skeletal form. Finally, this study contributes evidence that calls for a re-evaluation of phalangeal curvature as an exclusively locomotor signal and highlights the need to incorporate manipulative behavior into interpretations of hand bone morphology in both extant and fossil hominins and other primates.

Study funded in part by the U.S. National Science Foundation and The Leakey Foundation.

References: [1] Prang, T.C., Ramirez, K., Grabowski, M., Williams, S.A., 2021. *Ardipithecus* hand provides evidence that humans and chimpanzees evolved from an ancestor with suspensory adaptations. *Science Advances*. 7. [2] Wennemann, S.E., Lewton, K.L., Orr, C.M., Almécija, S., Tocheri, M.W., Jungers, W.L., Patel, B.A., 2021. A geometric morphometric approach to investigate primate proximal phalanx diaphysis shape. *American Journal of Biological Anthropology*. 177, 581–602. [3] Christel, M.I., Frigaszy, D.M., 2019. Object grasping and manipulation in capuchin monkeys (genera *Cebus* and *Sapajus*). *Biological Journal of the Linnean Society* 127, 563–582.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## Tracing cold-climate adaptations in early *Homo sapiens* in Europe: lipid biomarker and micromorphological evidence from Bacho Kiro Cave (Bulgaria)

Sarah Pederzani<sup>1,2</sup>, Carolina Mallol<sup>1</sup>, Javier Davara<sup>1</sup>, Antonio V. Herrera Herrera<sup>1</sup>, Lucía Castellano-Rotger<sup>1</sup>, Natalia Égüez<sup>1,3</sup>, Shannon P. McPherron<sup>4</sup>, Zeljko Rezek<sup>5</sup>, Nikolay Sirakov<sup>6</sup>, Tsenka Tsanova<sup>7</sup>, Jean-Jacques Hublin<sup>5</sup>, Vera Aldeias<sup>8</sup>

1 - Archaeological Micromorphology and Biomarkers Laboratory (AMBI Lab), Instituto Universitario de Bio-Organica “Antonio González”, University of La Laguna, San Cristóbal de La Laguna, Tenerife, Spain · 2 - Department of Geology & Geophysics, University of Utah, Salt Lake City, Utah, USA · 3 - Departamento de Ciencias de la Vida y de la Tierra, Instituto de Productos Naturales y Agrobiología, Consejo Superior de Investigaciones Científicas (IPNA-CSIC), San Cristóbal de La Laguna, Tenerife, Spain · 4 - Department of Human Origins, Max-Planck-Institute for Evolutionary Anthropology, Leipzig, Germany · 5 - Chaire de Paléanthropologie, CIRB (UMR 7241 – U1050), Collège de France, Paris, France · 6 - National Institute of Archaeology and Museum, Bulgarian Academy of Sciences, Sofia, Bulgaria · 7 - Department of Chemistry G. Ciamician, Alma Mater Studiorum, University of Bologna, Bologna, Italy · 8 - Interdisciplinary Center for Archaeology and Evolution of Human Behaviour (ICArEHB), Universidade do Algarve, Faro, Portugal

Reconstructing the timing and mechanisms of early *Homo sapiens*' adaptations to cold climates and new habitats is essential for interpreting their Late Pleistocene dispersals and evolutionary resilience. Recently, new evidence from early *H. sapiens* occupations in Europe has shown that the dispersal of several Upper Palaeolithic groups into Europe coincides with subarctic climates as early as ~45-43 ka cal BP [1,2]. However, how these groups of *H. sapiens* were able to adapt to such harsh environments remains largely unknown.

Here we provide new evidence for *H. sapiens* fire use behavior during one such cold-climate occupation - the Initial Upper Palaeolithic (IUP) at Bacho Kiro Cave, Bulgaria. Fire use represents a potentially important behavioral strategy for survival in cold conditions but data from early *H. sapiens* dispersals into harsher climatic zones is scarce. We use lipid biomarker analysis, soil micromorphology, and micro-X-ray fluorescence mapping to illuminate on the formation of the Bacho Kiro Cave IUP deposits and characterize combustion residues contained therein.

Micromorphological data suggests that the IUP deposits (Layer I) are mainly formed through anthropogenic actions and represent an unorganized mixture of both burned and unburned material, likely formed by site maintenance and dumping activities. Lipid biomarker analysis shows a similar variability of combustion evidence in the IUP samples, while samples from the underlying Middle Palaeolithic (MP) show little evidence of combustion inputs. *n*-Alkane and *n*-alkanal long-chain length distribution patterns indicate higher terrestrial plant inputs in all samples and these lipids are dominant in the MP samples. However, all IUP samples additionally show significant amounts of short chain *n*-alkanes peaking at ~C<sub>18</sub>, typical of thermal degradation or incomplete combustion of biomass at >300°C. Importantly, we also detect symmetrical long-chain ketones (K<sub>29</sub>, K<sub>31</sub>, K<sub>33</sub>) in two IUP samples. These compounds form during high-temperature (>350°C) degradation of fatty acids and are most commonly linked to heated animal fat residues. Microscopic charred bone fragments are abundant in the IUP deposits, though few are calcined to temperatures above ~700°C. The variability of combustion evidence suggests that inputs to the IUP deposits are comprised of a mix of unburned and thermally altered residues, supporting the micromorphological evidence of distinct human dumping and site maintenance activities during the IUP occupations. Additional investigation using stable isotope analysis of fatty acids and ongoing analysis of aromatic compounds are necessary to confirm an animal-fat origin of these compounds and better characterize the types of fuel used. If true, our findings would represent one of very few robust findings of animal fat combustion in the Palaeolithic record that warrants further investigation into the role of animal-derived fuel as an adaptation to cold climates.

This research was funded by the European Research Council grant MATRIX (project no. 101041245) awarded to V.A. S.P. was supported by the German Academy of Sciences Leopoldina (Postdoctoral Fellowship LPDS 2021-13) and by the National Science Foundation (award EAR-2202880) during work on this research.

References: [1] Pederzani, S., Britton, K., Aldeias, V., Bourgon, N., Fewlass, H., Lauer, T., McPherron, S.P., Rezek, Z., Sirakov, N., Smith, G.M., Spasov, R., Tran, N.-H., Tsanova, T., Hublin, J.-J., 2021. Subarctic climate for the earliest *Homo sapiens* in Europe. *Science Advances*. 7, eabi4642. [2] Pederzani, S., Britton, K., Trost, M., Fewlass, H., Bourgon, N., McCormack, J., Jaouen, K., Dietl, H., Döhle, H.-J., Kirchner, A., Lauer, T., Le Corre, M., McPherron, S.P., Meller, H., Mylopotamitaki, D., Orschiedt, J., Rougier, H., Ruebens, K., Schüler, T., Sinet-Mathiot, V., Smith, G.M., Talamo, S., Tütken, T., Welker, F., Zavalá, E.I., Weiss, M., Hublin, J.-J., 2024. Stable isotopes show *Homo sapiens* dispersed into cold steppes ~45,000 years ago at Ilsenhöhle in Ranis, Germany. *Nature Ecology & Evolution*. 8, 578–588.

Podium Presentation, Session 6, Friday 16:00 – 17:40

## Dating the European Palaeolithic (with a couple of Quaternary quandaries)

Kirsty Penkman<sup>1</sup>, Eleanor Nelson<sup>1</sup>, Pierre Antoine<sup>2</sup>, Nick Ashton<sup>3</sup>, Debra Colarossi<sup>4</sup>, Julie Dabkowski<sup>2</sup>, Robert Davis<sup>3</sup>, Thomas Daniel<sup>5</sup>, Gaudenz Deplazes<sup>6</sup>, Marc Dickinson<sup>1</sup>, Geoffrey Duller<sup>4</sup>, Lukas Gegg<sup>7</sup>, Samantha Greeves<sup>1</sup>, Michael Hein<sup>8</sup>, Michal Horsák<sup>9</sup>, Jarod Hutson<sup>10,11</sup>, Olaf Jöris<sup>10</sup>, Lucie Juříčková<sup>12</sup>, Nicole Limondin-Lozouet<sup>2</sup>, Lutz Maul<sup>13</sup>, Richard McIntosh<sup>14</sup>, Tom Meijer<sup>15</sup>, Stefan Meng<sup>16</sup>, Simon Parfitt<sup>17</sup>, Richard Preece<sup>18</sup>, Zoltan Püspöki<sup>19</sup>, Helen M. Roberts<sup>4</sup>, Balint Szappanos<sup>19</sup>, Marcin Szymanek<sup>20</sup>, Nigel Thew<sup>21</sup>, Joachim Wedel<sup>22</sup>, Lucy Wheeler<sup>1</sup>, Frank Wesselingh<sup>23</sup>, Dustin White<sup>1</sup>

1 - Department of Chemistry, University of York, United Kingdom · 2 - CNRS – Laboratoire de Géographie Physique: environnements quaternaires et actuels, UMR8591 Université Paris 1 Panthéon-Sorbonne, Université Paris Est-Créteil, Thiais, France · 3 - Department of Britain, Europe and Prehistory, British Museum, London, UK · 4 - Department of Geography and Earth Sciences, Aberystwyth University, Aberystwyth, UK · 5 - Institute of Earth Sciences, Friedrich Schiller University of Jena · 6 - NAGRA - Nationale Genossenschaft für die Lagerung radioaktiver Abfälle, Switzerland · 7 - Institute of Earth and Environmental Sciences, Universität Freiburg, Albertstraße 23b, 79104 Freiburg im Breisgau, Germany · 8 - Institute of Ecology, Leuphana University, Lüneburg, Germany · 9 - Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic · 10 - MONREPOS Archaeological Research Centre and Museum for Human Behavioural Evolution, Neuwied, Germany · 11 - Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, USA · 12 - Department of Zoology, Faculty of Science, Charles University, Prague, Czech Republic · 13 - Senckenberg Research Station of Quaternary Palaeontology, Weimar, Germany · 14 - Department of Mineralogy and Geology, University of Debrecen, Debrecen, Hungary · 15 - Naturalis Biodiversity Center, The Netherlands · 16 - Institut für Geographie und Geologie, Universität Greifswald, Germany · 17 - University College London, Institute of Archaeology & Natural History Museum, London, UK · 18 - University Museum of Zoology Cambridge, UK · 19 - Supervisory Authority for Regulatory Affairs, Budapest, Hungary · 20 - Warsaw University, Faculty of Geology, Warsaw, Poland · 21 - Rue Paul Bouvier 2, 2000 Neuchâtel, Switzerland · 22 - Hessisches Landesamt für Naturschutz, Umwelt und Geologie, Wiesbaden, Germany · 23 - Nederlands Centrum voor Biodiversiteit Naturalis, The Netherlands

The Quaternary geological, palaeontological and archaeological records in Europe are the most extensively studied in the world, providing a detailed history of the climatic and environmental changes critical to understanding our human story. However, most of the sites only cover a short (and often poorly constrained) time period, recording only snapshots of time which have little meaning without a securely dated independent timescale. This severely limits our understanding of the European Palaeolithic and palaeoclimate.

To help refine the chronology for this period, over the last few years the EQuaTe project has analysed fossil biominerals from hundreds of sites to build regional aminostratigraphic dating frameworks. Our selected study regions range from the British Isles to the East European Plain, bounded by the Pyrenees, Alps, Caucasus and Urals, covering a macro-region beyond potential refugia, where human populations would have been dynamic and highly adaptive, and for which repopulation could have been from different regions.

Use of different biominerals (e.g. snail opercula, shell fragments, tooth enamel, slug plates, worm granules, Foraminifera) enables us to extend the range of dateable environments. Using intra-crystalline amino acids, these aminostratigraphies provide a relative timescale for each region that have been pinned to numerical dates and other independent evidence of age at key sites. Through this we have been able to develop a better understanding of how temperature impacts the rates of the protein breakdown, and thereby how to stitch the regional amino acid dating frameworks together.

We now have a Pleistocene dating framework that can be used to test models and hypotheses for the Palaeolithic in Britain, the Seine and Somme river terraces (France), the Netherlands, Czechia, the Pannonian Basin (Hungary), Thuringia, the Rhineland and the Northern German Plain (Germany), the Swiss Plateau, and Poland. But very occasionally, the results raise more questions than they answer! A couple of sites have yielded unexpected ages, and we discuss these challenges and how they progress our understanding of the past.

This project (EQuaTe) has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 865222).

Poster Presentation Number 116, Session 0, day 00:

## Locomotor behavior of bonobos *Pan paniscus*: implications for understanding the positional behaviour of early hominins

Amira Perrot<sup>1,2</sup>, François Druelle<sup>3</sup>, Victor Narat<sup>2</sup>, Gilles Berillon<sup>1</sup>

1 - UMR 7194, Histoire Naturelle des Humanités Préhistoriques, CNRS-MNHN-UPVD, Paris, France · 2 - UMR 7206, Eco-Anthropologie, CNRS-MNHN, Paris, France · 3 - UMR 7268, Anthropologie bio-culturelle, Droit, Ethique et Santé, AMU-CNRS-EFS, Marseille, France

The evolution of locomotor behaviors in the hominin lineage remains highly debated, particularly regarding the possible locomotor diversity of early hominins. Fossil evidence suggests that these species exhibited a diverse set of locomotor abilities (see, for example, *Sabelanthropus tchadensis* [1]). These hypotheses support the idea that early hominins had a generalized locomotor repertoire, involving several major locomotor modes modulated in response to environmental context and substrate properties. Observational studies of extant great apes in natural settings are a valuable resource for exploring how locomotor behaviors, in species with a rather generalist morphology, interact with environmental variables (e.g., forest strata, substrate properties). While chimpanzees (*Pan troglodytes*) have been extensively studied across a variety of habitats (forests, savannah, etc.), behavioral data on bonobos (*Pan paniscus*) in natural settings remain limited [2,3]. This project aims to provide new comparative data on bonobo positional behavior and to further investigate its complexity, with a focus on how substrate properties influence locomotor strategies.

Here, we studied the bonobo community of Manzano (Bolobo Territory, Democratic Republic of Congo). This bonobo community lives in a forest–savanna mosaic environment and is well habituated to human observers. The aim was to describe the posturo-locomotor repertoire and analyze its variation across age–sex classes and substrate characteristics (height, size, compliance, inclination). Data were collected from 30 individuals using instantaneous scan sampling and continuous focal video recordings.

Results from continuous focal sampling in the forest environment show that the adult arboreal locomotor repertoire relies primarily on vertical climbing, pronograde walking, orthograde suspension, and orthograde walking which is performed in a lower proportion. Age-related variation was observed, with infants showing a strong preference for walking modes, both pronograde and orthograde, that represent the majority of their repertoire. Across all age classes combined, pronograde walking occurred mainly above 20 m height, on large and rigid substrates offering greater stability. In contrast, suspension and vertical climbing were used across all substrate properties, including the most compliant ones.

These findings support the interpretation of bonobos as generalist primates capable of moving on all kinds of arboreal substrates in modulating their repertoire. When compared to the arboreal positional behavior of Lomako bonobos [2] and Issa chimpanzees [3], all three communities exhibited locomotor behavior distributed across several major modes, without a single dominant one as in more specialized primates. Vertical climbing was more frequent in chimpanzees, while the proportions of walking modes were similar across species. However, bonobos exhibited a higher frequency of suspensory behaviors than chimpanzees, which is consistent with their tendency to exhibit a more gracile morphology and a lower body weight [4]. These results highlight both ontogenetic variation and behavioral flexibility in response to environmental constraints in bonobos. Integrating these new data on bonobos with those available for great apes invites our community to discuss the complexity and the flexibility of early hominins positional behavior.

This PhD project is funded by the IBEEs initiative of Sorbonne University (France). I gratefully acknowledge the support of the field research assistants during data collection. Fieldwork was possible thanks to the support of the NGO Mbou-Mon-Tour and the association Bonobo Eco and was financially supported by the Société des Amis du Muséum and the MITI program of the CNRS. The study site of Manzano is a long-term research site recognized with the CNRS SEE-LIFE label.

References: [1] Dayer, G., Guy, F., Mackaye, H.T., Likius, A., Boissier, J.-R., Moussa, A., Pallas, L., Vignaud, P., Clarisse, N.D., 2022. Postcranial evidence of late Miocene hominin bipedalism in Chad. *Nature*. 609, 94–100. [2] Doran, D.M., 1993. Comparative locomotor behavior of chimpanzees and bonobos: The influence of morphology on locomotion. *American Journal of Physical Anthropology*. 91, 83–98. [3] Drummond-Clarke, R.C., Kivell, T.L., Sarringhaus, L., Stewart, F.A., Piel, A.K., 2024. Sex differences in positional behavior of chimpanzees (*Pan troglodytes schweinfurthii*) living in the dry and open habitat of Issa Valley, Tanzania. *American Journal of Biological Anthropology*. 185. [4] Druelle, F., Schoonaert, K., Aerts, P., Nauwelaerts, S., Stevens, J.M.G., D'Août, K., 2018. Segmental morphometrics of bonobos (*Pan paniscus*): are they really different from chimpanzees (*Pan troglodytes*)? *Journal of Anatomy*. 233, 843–853.

Podium Presentation, Session 9, Saturday 14:00 – 15:20

## A new Denisovan genome sheds light on the peopling of Asia and Oceania

Stéphane Peyrégne<sup>1</sup>, Diyendo Massilani<sup>1,2</sup>, Yaniv Swiel<sup>1</sup>, Arev P. Sümer<sup>1</sup>, Alba Bossoms Mesa<sup>1</sup>, Michael James Boyle<sup>1,2</sup>, Leonardo N. M. Iasi<sup>1</sup>, Cesare de Filippo<sup>1</sup>, Bence Viola<sup>3</sup>, Elena Essel<sup>1</sup>, Sarah Nagel<sup>1</sup>, Julia Richter<sup>1</sup>, Antje Weihmann<sup>1</sup>, Barbara Schellbach<sup>1</sup>, Hugo Zeberg<sup>1,4</sup>, Johann Visagie<sup>1</sup>, Maxim B. Kozlikin<sup>5</sup>, Michael V. Shunkov<sup>5</sup>, Anatoly P. Derevianko<sup>5</sup>, Kay Prüfer<sup>1</sup>, Benjamin M. Peter<sup>1</sup>, Matthias Meyer<sup>1</sup>, Svante Pääbo<sup>1</sup>, Janet Kelso<sup>1</sup>

1 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 2 - Current address: Department of Genetics, Yale School of Medicine, New Haven, CT, USA · 3 - Department of Anthropology, University of Toronto, Toronto, Ontario, Canada · 4 - Department of Physiology and Pharmacology, Karolinska Institutet, Stockholm, Sweden · 5 - Institute of Archaeology and Ethnography, Siberian Branch, Russian Academy of Sciences, Novosibirsk, Russia

While it is widely accepted that modern humans arose in Africa, the timing of the initial arrival and survival of modern humans in different regions of the world remains unresolved. Archaeological evidence suggests multiple dispersals of modern humans out of Africa, with some fossil finds supporting early modern human presence in China by 100 thousand years ago (ka) and in Southeast Asia by 70 ka. However, genomic data suggests that people living today descend primarily from a single rapid dispersal after 50 ka, as all non-Africans carry Neandertal ancestry from a shared admixture event. Genetic contributions from earlier migrations, if any, were minimal (<1%), but uncertainties persist regarding the relationships and migration routes of ancestral populations across Eurasia and Oceania.

Investigating interactions between early modern humans and Denisovans, archaic humans who lived in Asia before modern humans, can shed light on these dispersal(s). Previous work has shown that the ancestors of present-day Asians and Oceanians met and mixed with multiple, genetically distinct Denisovan populations. However, the availability of only a single high-quality Denisovan genome has constrained our ability to characterise the diversity of Denisovan ancestry in modern humans and reconstruct the history of interactions.

We report a second high-quality Denisovan genome reconstructed from a molar found at Denisova Cave and dated to around 200 ka. We determined that this individual belonged to an early Denisovan population that split about 220 ka from later Denisovans at the cave. Using this new Denisovan genome we reassess the distribution of different Denisovan ancestry components in present-day people. The geographic distribution of these components today offers clues about where Denisovans lived and the routes taken by modern humans as they colonised Asia and Oceania. Furthermore, comparisons of introgressed Denisovan DNA segments across populations and estimates of the times of introgression shed light on the number and timing of these migrations. These findings offer a new perspective on the history of early modern human dispersals.

Poster Presentation Number 117, Session 2, Friday 14:00 - 15:30

## The human deciduous molar found in the Lower Palaeolithic layer from the Observatoire Cave (Principality of Monaco): a taxonomic assessment

Erica Piccirilli<sup>1</sup>, Matteo Romandini<sup>1</sup>, Antonino Vazzana<sup>1</sup>, Rita Sorrentino<sup>2</sup>, Francesco Fontani<sup>1</sup>, Alessandra Modi<sup>3</sup>, Gregorio Oxilia<sup>4</sup>, Owen Alexander Higgins<sup>1</sup>, Sara Silvestrini<sup>1</sup>, Shara E. Bailey<sup>5</sup>, Abdelkader Moussous<sup>6</sup>, Giovanni di Domenico<sup>7</sup>, David Caramelli<sup>3</sup>, Jean-Jacques Hublin<sup>8,9</sup>, Olivier Notter<sup>6</sup>, Elena Rossoni-Notter<sup>6</sup>, Stefano Benazzi<sup>1</sup>

1 - Department of Cultural Heritage, University of Bologna, Ravenna, Italy · 2 - Department of Biological, Geological and Environmental Sciences, University of Bologna, Bologna, Italy · 3 - Department of Biology, University of Florence, Florence, Italy · 4 - Department of Medicine and Surgery, "LUM" Giuseppe Degennaro Casamassima, Casamassima, Italy · 5 - Department of Anthropology, Center for the Study of Human Origins, New York University, New York, USA · 6 - Museum of Prehistoric Anthropology of Monaco founded by Prince Albert I, Monaco · 7 - Department of Physics and Earth Science, University of Ferrara, Ferrara, Italy · 8 - Chaire de Paléanthropologie, CIRB, Collège de France, Université PSL, CNRS, Paris, France · 9 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

The Liguro-Provençal corridor, spanning present-day southeastern France and western Italy, reveals continuous human presence from the Lower to Upper Palaeolithic, owing to the lithic and faunal finds and the abundant human fossil record. Among the numerous sites of this region, Observatoire Cave, situated in Monaco's Exotic Garden, bears the earliest archaeological evidence of human occupation in the Principality of Monaco. First excavated in 1916-1920 by Léonce de Villeneuve, under the reign of Prince Albert I of Monaco, its investigation continued under the direction of Louis Barral and Suzanne Simone in the 1950s and 1980s, alongside restoration and musealization works. Since 2016, Olivier Notter and Elena Rossoni-Notter have resumed excavations in the older levels. More than a century's worth of work has revealed a rich archaeo-stratigraphic sequence, consisting of three techno-cultural macro-complexes: the upper complex, with Proto-Aurignacian, Aurignacian and Gravettian occupations, the middle complex, including Mousterian occupations, and the lower complex, characterized by Acheulean-Clactonian and Pre-Mousterian occupations [1]. In 2020, during the excavation of the lowest archaeological levels of the cave, a human tooth (Obs1) was recovered from sieved sediments coming from the surface and against the wall of the site. To date, this is the only human remains found in a Palaeolithic context in the Principality of Monaco, and its recovery from Lower Palaeolithic levels initially suggested it was dated to this period.

Here, we provide a morphological description and 2D geometric morphometrics (GM) analysis, aimed at clarifying its taxonomic attribution, accompanied by a pathological and taphonomic study. Routine digital workflows were applied to create the 3D model of the tooth tissues, and a 2D GM analysis of the crown outline was performed [2]. A genetic analysis of Obs1 was also conducted [3].

Obs1 is an upper right second deciduous molar, with four main cusps. It also has well-developed cusp-like expression of Carabelli's trait, which is common in Neanderthals and *Homo sapiens*, but rare-to-absent in earlier hominins. We also observed deep tooth-pick groove filled with concretion on the distal cervical margin. The results of the 2D GM analysis of the crown outline plot Obs1 near Upper Palaeolithic *H. sapiens* individuals and within the variability of recent *H. sapiens*, outside the variation of early *H. sapiens* and far from Neanderthals. The DNA of Obs1 revealed contamination with exogenous human genetic material. The microscope-aided observation of the tooth-pick groove suggests intentional behaviour related to cleaning or pain-relief, as commonly documented in Middle and Upper Palaeolithic contexts [4,5]. In conclusion, our results support an attribution of Obs1 to *H. sapiens*, most likely an Upper Palaeolithic child, as no more recent occupation of the site has been attested. Current evidence points to a possible accidental displacement of Obs1 from an Upper Palaeolithic layer into an older layer during earlier restoration works. Therefore, we could reject the initial hypothesis of an earlier origin, as assumed by stratigraphy. Obs1 represents the oldest human fossil found to date in Monaco. We hypothesize that it is likely linked to the Proto-Aurignacian, Aurignacian, or Gravettian period.

The authors are grateful to the Government of the Principality of Monaco and to the Department of Cultural Affairs and the City Hall (Mairie) of Monaco for the support to the research. The contribution of M.R. and S.B. was funded by CHANGES, SPOKE 5 "Science and Technologies for 100 Sustainable Diagnostics of Cultural Heritage," PE 0000020, CUP B53C22003890006, NRP M4C2 101 Investment 1.3, funded by the European Union—NextGenerationEU.

References: [1] Rossoni-Notter, E., Notter, O., Simone, S., Simon, P., 2016. Acheulean in Monaco: Observatoire cave and its singular occupations. *Quaternary International*. 411, 212–235. [2] Lugi, F., Nava, A., Sorrentino, R., Vazzana, A., Bortoni, E., Oxilia, O., Silvestrini, S., Nannini, N., Bondioli, L., Fewlass, H., Talamo, S., Bard, E., Mancini, L., Müller, W., Romandini, M., Benazzi, S., 2022. Tracing the mobility of a Late Epigravettian (~13 ka) male infant from Grotte di Pradis (Northeastern Italian Prealps) at high-temporal resolution. *Scientific Reports*. 12, 8104. [3] Fellows Yates, J.A., Lamnidis, T.C., Borry, M., Valtueña, A.A., Fagernäs, Z., Clayton, S., Garcia, M.U., Neukamm, J., Peltzer, A., 2021. Reproducible, portable, and efficient ancient genome reconstruction with nf-core/eager. *PeerJ*. 9, e10947. [4] Lozano, M., Subirà, M.E., Aparicio, J., Lorenzo, C., Gómez-Merino, G., 2013. Toothpicking and Periodontal Disease in a Neanderthal Specimen from Cova Foradà Site (Valencia, Spain). *PLoS ONE*. 8. [5] Ricci, S., Capocchi, G., Boschini, F., Arrighi, S., Ronchitelli, A., Condemni, S., 2016. Toothpick use among Epigravettian Humans from Grotta Paglicci (Italy). *International Journal of Osteoarchaeology*. 26, 281–289.

Poster Presentation Number 118, Session 2, Friday 14:00 - 15:30

## Piekary III in context: new data on lithic technology and chronology from a stratified open-air site in southern Poland

Andrea Picin<sup>1</sup>, Andrzej Jacek Tomaszewski<sup>2</sup>, Damian Stefański<sup>3</sup>, Sahra Talamo<sup>1</sup>

1 - Department of Chemistry G. Ciamician, University of Bologna, Bologna, Italy · 2 - State Archaeological Museum Warsaw, Warsaw, Poland · 3 - Archaeological Museum in Kraków, Krakow, Poland

During the Late Pleistocene, human settlement in Central Europe was strongly influenced by climatic oscillations. Dispersals into regions north of 45°N, including southern Poland, occurred primarily during environmentally favorable phases [1]. Archaeological and environmental evidence indicates that this region functioned as a satellite zone within the broader settlement system of prehistoric hunter-gatherers, periodically revisited for the exploitation of seasonal resources [2-4]. Expanding the chronometric dataset for Pleistocene sites is therefore essential to refine the timing of Neanderthal and *Homo sapiens* occupations in this area.

The Kraków region, intensively investigated since the late 19th century, preserves a rich archaeological record of Middle and Upper Paleolithic sites. Among these, the Piekary complex, situated on the left bank of the Vistula River at the eastern margin of the Kraków Gate, is particularly significant. It includes a cluster of open-air and cave sites such as Piekary I (Jama Cave), II, IIa, III, IV (Na Gołabcu Cave), and V. Piekary III stands out for its stratified sequence, first tested by Krukowski in 1927 and excavated in 1936 across 360 m<sup>2</sup>. The stratigraphy comprises nine layers, with Layer 9 lying directly on Jurassic limestone. Micoquian artifacts were found in Layer 8, while Layer 7 yielded the richest lithic assemblage, followed by Layers 6 and 5 with fewer finds. Layer 2 contained Neolithic pottery sherds [5]. Due to limited documentation, however, the association between artifacts and specific layers remains tentative.

This study presents new radiocarbon dates for eight bone samples and a technological reassessment of the Piekary III lithic industry. Given potential vertical mixing, the assemblage was analyzed as a whole. Particular focus was placed on cores, asymmetrical bifacial knives, flakes, and retouched tools. Technological analysis identified a substantial Micoquian component characteristic of the Central-Eastern European Micoquian (CEEM), including Keilmesser, bifacial and Quina scrapers, groszaks, and Mousterian points. The core assemblage aligns with CEEM techno-complexes, with a dominance of hierarchized and simple unidirectional cores and limited use of Levallois and discoid methods. Upper Paleolithic artifacts were also identified, including massive blade cores and carinated end-scrapers suggestive of an Aurignacian occupation, and blade/bladelet cores likely attributable to the Late Gravettian.

To refine the site's chronology, collagen was extracted using ultrafiltration protocols at the BRAVHO Radiocarbon Laboratory (Bologna), and radiocarbon dating was conducted at the Klaus-Tschira-AMS facility in Mannheim. Results indicate that the main occupation (Layer 7) occurred around 45–44 ka BP, followed by occupations dated to 42–41 ka BP in Layer 5. Two samples from Layer 6 are considered outliers: one likely redeposited from Layer 5 (42 ka BP) and one dated to 26–25 ka BP, indicating a later Gravettian presence.

The integration of technological and chronological data offers new insights into the occupational sequence at Piekary III. Neanderthal presence is now securely dated to MIS 3, while the Aurignacian and Late Gravettian components mirror ephemeral Upper Paleolithic occupations at nearby sites such as Piekary II, IIa, Kraków-Księcia Józefa Street, and Kraków-Zwierzyniec 1. Piekary III thus emerges as an important locality for reconstructing the dynamics of human settlement in southern Poland, underscoring the cyclical and discontinuous nature of Neanderthal and *Homo sapiens* occupations in this region.

This research has been supported by the Italian Ministry of University and Research - project FIS-2023-01196 POOL - Investigating cultural and biological scenarios of late Neanderthals and *Homo sapiens* in Poland (awarded to A.P.); German Research Foundation - DFG project 429271700 STONE - Spread and Technology of Neanderthals in Periglacial Environment (awarded to A.P.).

References: [1] Picin, A., 2025. Neanderthals' recolonizations of marginal areas: An overview from Eastern Germany. *Quaternary Science Advances*. 17, 100260. [2] Picin, A., Hajdinjak, M., Nowaczewska, W., Benazzi, S., Urbanowski, M., Marciszak, A., Fewlass, H., Bosch, M.D., Socha, P., Stefaniak, K., Zarski, M., Wiśniewski, A., Hublin, J.-J., Nadachowski, A., Talamo, S., 2020. New perspectives on Neanderthal dispersal and turnover from Stajnia Cave (Poland). *Scientific Reports*. 10. [3] Picin, A., Stefański, D., Cieśla, M., Valde-Nowak, P., 2023. The beginning of the Early Upper Paleolithic in Poland. *Journal of Paleolithic Archaeology*. 6. [4] Talamo, S., Nowaczewska, W., Picin, A., Vazzana, A., Binkowski, M., Bosch, M.D., Cercatillo, S., Diakowski, M., Fewlass, H., Marciszak, A., Paleček, D., Richards, M.P., Ryder, C.M., Sinet-Mathiot, V., Smith, G.M., Socha, P., Sponheimer, M., Stefaniak, K., Welker, F., Winter, H., Wiśniewski, A., Zarski, M., Benazzi, S., Nadachowski, A., Hublin, J.-J., 2022. Author Correction: A 41,500 year-old decorated ivory pendant from Stajnia Cave (Poland). *Scientific Reports*. 12. [5] Tomaszewski, A.J., 2004. Aperçus des matériaux du Paléolithique moyen du site Piekary III, In: Sachse-Kozłowska, E., Kozłowski, S.K. (Eds.), *Piekary près de Cracovie (Pologne) complexe de sites Paléolithiques*, PAU, Kraków, p. 111-142.

Poster Presentation Number 119, Session 2, Friday 14:00 - 15:30

## Cutting edge technology at Obi-Rakhmat 80,000 years ago

Hugues Plisson<sup>1</sup>, Alëna V. Kharevich<sup>2</sup>, Vladimir M. Kharevich<sup>2</sup>, Pavel V. Chistiakov<sup>2</sup>, Lydia V. Zotkina<sup>2</sup>, Malvina Baumann<sup>3,4</sup>, Eric Pubert<sup>1</sup>, Ksenya A. Kolobova<sup>2</sup>, Farhod A. Maksudov<sup>5</sup>, Andrei I. Krivoschapkin<sup>6</sup>

1 - PACEA UMR5199, Université de Bordeaux, France · 2 - Institute of Archaeology and Ethnography SB RAS, Novosibirsk, Russian Federation · 3 - Traceolab, Université de Liège, Belgium · 4 - Zoostan, IRL 2033, CNRS & KazNU, Almaty, Kazakhstan · 5 - National Center of Archeology, Tashkent, Uzbekistan · 6 - APSACA, National Center of Archeology, Tashkent, Uzbekistan

Instrumented hunting is a distinctive trait of the *Homo* genus. Given the impact of meat consumption on hominization, both cognitively and behaviourally, the search for archaeological evidence of past weaponry is of primary importance, with a particular attention to the oldest occurrences. Lithic weapon heads occasionally found in Middle Paleolithic Neanderthal sites are large and do not differ in size, shape or type from those used in other activities such as butchering or plant gathering. The presence in a same assemblage of various types of projectile armatures, some of which are microlithic and designed for this purpose, has so far only been documented at sites occupied by modern humans. An increasing number of studies show that the small or medium-sized lithic points that form part of the typological characterisation of the Initial or Early Upper Palaeolithic assemblages were projectile heads, some of which were probably delivered mechanically [1-3]. They mark a technical break with the Middle Palaeolithic; from then on, projectile armatures will become the central structuring element of lithic industries. We present the initial findings of our search for weapon points in the oldest layers of the Obi-Rakhmat rock shelter in Uzbekistan dating back around 80 ka. The lithic industry of this settlement is forming part of the Levantine Early Middle Paleolithic continuity but with several innovative traits.

This site, located in the western foothills of the Tian Shan Mountains, north-eastern Uzbekistan, has yielded throughout 10 meters of Pleistocene deposits a lithic industry characterized by the production of regular thick narrow blades from unipolar and bipolar sub-prismatic and narrow-faced cores, thin and wide blades from flat-faced Levallois-like cores along with shorter pieces from convergent or centripetal Levallois cores, and bladelets from burin-cores and other small cores. Three types of projectile armature are identified on the basis of their impact traces in the lithic assemblage from levels 20 and 21: retouched points, bladelets and more particularly unretouched triangular micro points, which had previously gone unnoticed due to their fragmentary state. According to the fundamental principles of hunting weapon design (e.g. [4-5]), these micro points are too narrow for having been fitted to anything other than arrow-like shafts. They resemble the armatures described in a pioneer settlement by Sapiens in the Rhône Valley, France, 25,000 years later [3].

This research would not have been possible without support from: International Research Laboratory ARTEMIR, Russian Science Foundation project RSF 22-18-00649, International Research Laboratory Zoostan, Institut français d'études sur l'Asie centrale.

References: [1] Sano, K., Arrighi, S., Stani, C., Aureli, D., Boschin, F., Fiore, I., Spagnolo, V., Ricci, S., Crezzini, J., Boscato, P., Gala, M., Tagliacozzo, A., Birarda, G., Vaccari, L., Ronchitelli, A., Moroni, A., Benazzi, S., 2019. The earliest evidence for mechanically delivered projectile weapons in Europe. *Nature Ecology & Evolution*. 3, 1409–1414. [2] Yaroshevich, A., Kaufman, D., Marks, A., 2021. Weapons in transition: Reappraisal of the origin of complex projectiles in the Levant based on the Boker Tachtit stratigraphic sequence. *Journal of Archaeological Science*. 131, 105381. [3] Metz, L., Lewis, J.E., Slimak, L., 2023. Bow-and-arrow, technology of the first modern humans in Europe 54,000 years ago at Mandrin, France. *Science Advances*. 9. [4] Bleed, P., 1986. The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity*. 51, 737–747. [5] Hughes, S.S., 1998. Getting to the point: Evolutionary change in prehistoric weaponry. *Journal of Archaeological Method and Theory*. 5, 345–408.

Poster Presentation Number 120, Session 2, Friday 14:00 - 15:30

## Cute dogs and risky birth: a novel approach for understanding the human birth process

Victoria Poltze<sup>1</sup>, Guillermo Bravo Morante<sup>1</sup>, Henning Richter<sup>2</sup>, Karen Rosenberg<sup>3</sup>, Nicole Grunstra<sup>4,5</sup>, Martin Haeusler<sup>1</sup>

1 - Institute of Evolutionary Medicine, University of Zürich, Zürich, Switzerland · 2 - Diagnostic Imaging Research Unit (DIRU), Vetsuisse Faculty, University of Zürich, Zürich, Switzerland · 3 - Department of Anthropology, University of Delaware, Newark, Delaware, USA · 4 - Department of Evolutionary Biology, Unit for Theoretical Biology, University of Vienna, Vienna, Austria · 5 - Mammal Collection, Natural History Museum Vienna, Vienna, Austria

The evolutionary origin of the characteristic birth difficulty of modern humans has intrigued researchers for decades, as they seek to understand our unusually high maternal and neonatal mortality and morbidity relative to other mammals. The obstetrical dilemma hypothesis explains this risky birth process in humans as a trade-off between giving birth to large-brained offspring and a pelvis adapted for efficient bipedal locomotion leading to a shortened hipbone compared to the common ancestor with chimpanzees. This dilemma is mitigated by an increased neurological immaturity of the newborns as well as an augmented pelvic sexual dimorphism [1]. Despite its popularity, the obstetrical dilemma is currently the subject of a heated debate [2-3]. Critics particularly argue that the hypothesis suffers from lack of empirical testing. Moreover, the impact of a shortened hipbone on the difficult birth process, although already formulated within the original hypothesis [see 2], has rarely been investigated.

Birth is risky not only for humans, but also for certain dog breeds: a high prevalence of dystocia and Caesarean section rates exceeding 90% can be observed especially in small brachycephalic breeds such as French Bulldogs or Scottish Terriers [4]. Previous analyses suggested that these breeds have cranio-caudally shortened hipbones and dorso-ventrally narrower pelvic canals, as well as fetuses with relatively large heads [5]. These morphological changes of the pelvis, obtained through domestication and selective breeding, therefore represent a remarkable analogy to the evolutionary changes in pelvic morphology in early hominins related to bipedal locomotion. The study of these morphological changes helps to understand the evolutionary mechanisms behind our risky birth.

Here, we analyse pelvic shape and the degree of sexual dimorphism in French Bulldogs (N=25) compared to a range of other dog breeds (N=30) and wolves (N=35) as the ancestral form of all dog breeds. 3D meshes were obtained through 3D surface scans and segmentation of CT scans. The analysis was carried out using geometric morphometrics based on a landmark configuration with 63 fixed landmarks.

Our preliminary results indicate a clear morphological separation of wolves from domestic dog breeds and especially French Bulldogs in a principal component analysis. This mainly seems to be due to a shortening of the hipbone in French Bulldogs, leading to a more constricted true conjugate, diagonal conjugate and perpendicular sagittal diameter of the pelvic canal, while the transverse diameters of the pelvis were less affected. This supports our hypothesis of a correlation between dystocia and a shortening of the hipbone which in humans helped to bring the body centre of mass above and behind the hip joints and reduce the lever arms in the pelvis. As expected, there was also a trend for an increased degree of sexual dimorphism in French Bulldogs compared to wolves, with females having relatively larger birth canals, suggesting that the comparatively short time span of domestication of this dog breed might nonetheless have led to significant evolutionary changes in pelvic morphology.

These results contribute to the debate over the obstetrical dilemma by offering a rare non-primate analogy. In particular, we offer a first evaluation of the understudied impact of hipbone length on difficult birth in humans.

This study was funded through Swiss National Science grants No. 310030\_212984 and CRSK-3\_227386 / 1

References: [1] Rosenberg, K.R., 1992. The evolution of modern human childbirth. *American Journal of Physical Anthropology*. 35, 89–124. [2] Haeusler, M., Grunstra, N.D.S., Martin, R.D., Krenn, V.A., Fornai, C., Webb, N.M., 2021. The obstetrical dilemma hypothesis: there's life in the old dog yet. *Biological Reviews*. 96, 2031–2057. [3] Webb, N.M., Fornai, C., Krenn, V.A., Watson, L.M., Herbst, E.C., Haeusler, M., 2024. Gradual exacerbation of obstetric constraints during hominoid evolution implied by re-evaluation of cephalopelvic fit in chimpanzees. *Nature Ecology & Evolution*. 8, 2228–2238. [4] Münnich, A., Küchenmeister, U., 2009. Dystocia in Numbers – Evidence-Based Parameters for Intervention in the Dog: Causes for Dystocia and Treatment Recommendations. *Reproduction in Domestic Animals*. 44, 141–147. [5] Eneroth, A., Linde-Forsberg, C., Uhlhorn, M., Hall, M., 1999. Radiographic pelvimetry for assessment of dystocia in bitches: a clinical study in two terrier breeds. *Journal of Small Animal Practice*. 40, 257–264.

Poster Presentation Number 121, Session 2, Friday 14:00 - 15:30

## How does the number of landmarks impact geometric morphometric-based phylogenetic analysis?

Nicholas W. Post<sup>1,2,3</sup>, Ashley S. Hammond<sup>2,3</sup>, Kelsey D. Pugh<sup>2,3,4</sup>, Sergio Almécija<sup>2,3,5,6</sup>, and Santiago A. Catalano<sup>2,7,8</sup>

1 - Richard Gilder Graduate School, American Museum of Natural History, New York, USA · 2 - Division of Anthropology, American Museum of Natural History, New York, USA · 3 - New York Consortium in Evolutionary Primatology (NYCEP), New York, USA · 4 - Faculty of Arts & Sciences, OCAD University, ON, Canada · 5 - Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Barcelona, Spain (ICP CERCA) · 6 - ICREA, Pg. Lluís Companys 23, Barcelona, Spain · 7 - Unidad Ejecutora Lillo, Consejo Nacional de Investigaciones Científicas y Técnicas – Fundación Miguel Lillo, Tucumán, Argentina · 8 - Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán, Tucumán, Argentina

Recent works across vertebrate paleontology have employed datasets that include up to hundreds of landmarks (including semi-landmarks) to infer the phylogenetic relationships among taxa [1-3]. However, capturing shape with sufficient precision to reconstruct phylogeny may be accomplished with small numbers of landmarks, allowing for faster data collection than with large landmark datasets or discrete character matrices. To test this, we present a workflow to examine the performance of differing numbers of landmarks, analyzing a dataset of 209 cranial landmarks for 18 extant primate (three Platyrrhini, four Cercopithecidae, four Hylobatidae, seven Hominidae) and 9 fossil hominin taxa (*Homo sapiens*, *H. neanderthalensis*, African and Asian *H. erectus*, *H. naledi*, *H. floresiensis*, *H. heidelbergensis*, *H. habilis* and *Paranthropus boisei*). We first employ the LaSEC function in R to subset our landmark dataset to determine the minimum number of landmarks needed to capture 95% of shape information [4]. Then, we perform 1000 resampling iterations of random subsets of this number of landmarks in TNT v 1.6 [5]. Subsequently, we quantify the difference between trees generated in this manner and the most parsimonious tree constructed using the total landmark dataset by calculating the minimum SPR (subtree pruning and regrafting) moves needed to convert one tree to another. Finally, we iteratively repeat the analysis, starting with 100% of landmarks employed and decreasing this number by 10% until reaching only 20% of the total landmarks. Results demonstrate that relationships within the genus *Homo* remain largely stable regardless of landmark sampling, while positions of great apes and some earlier hominin taxa fluctuate. These results indicate that relatively few landmarks are needed to reconstruct a hominin phylogeny broadly consistent with previous morphological and molecular works. However, reconstruction of higher-level primate groups may require more or different types of information.

We thank Will Harcourt-Smith for his project feedback and assistance in procuring fossil casts. We thank Eva-Mercè Fuentes for her assistance in data preparation.

References: [1] Ascarrunz, E., Claude, J., Joyce, W.G., 2019. Estimating the phylogeny of geoemydid turtles (Cryptodira) from landmark data: an assessment of different methods. *PeerJ*. 7, e7476. [2] Jones, A.S., Butler, R.J., 2018. A new phylogenetic analysis of Phytosauria (Archosauria: Pseudosuchia) with the application of continuous and geometric morphometric character coding. *PeerJ*. 6, e5901. [3] Catalano, S.A., Torres, A., 2016. Phylogenetic inference based on landmark data in 41 empirical data sets. *Zoologica Scripta*. 46, 1–11. [4] Watanabe, A., 2018. How many landmarks are enough to characterize shape and size variation? *PLOS ONE*. 13, e0198341. [5] Goloboff, P.A., Catalano, S.A., 2016. TNT version 1.5, including a full implementation of phylogenetic morphometrics. *Cladistics*. 32, 221–238.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## The evolutionary singularity of human handedness

Thomas A. Püschel<sup>1</sup>, Rachel Hurwitz<sup>1</sup>, Chris Venditti<sup>2</sup>

1 - Institute of Human Sciences, School of Anthropology & Museum Ethnography, University of Oxford, UK · 2 - School of Biological Sciences, University of Reading, UK

The evolution of cross-cultural right-handedness in humans has long been debated. While manual lateralisation is not exclusive to our species, the near-universal 90% right-hand preference observed in humans represents an unparalleled extreme among primates. Despite this striking asymmetry often being regarded as uniquely human, the study of primate handedness, especially from a comparative perspective, has received relatively limited attention. However, examining manual lateralisation in non-human primates may offer valuable insights into the evolutionary origins of human handedness. A number of eco-evolutionary hypotheses have been proposed to explain right-hand bias in humans, involving factors such as tool use, diet, brain size, locomotion, and terrestriality. In this study, we address these questions by analysing data on hand preferences for standardised object manipulation tasks in 2,025 individuals across 41 species of anthropoid primates. We used two widely accepted metrics to characterise handedness: mean handedness index (MHI), indicating directional bias, and mean absolute handedness index (MABSHI), indicating strength of preference. Applying Bayesian phylogenetic comparative meta-analytical methods, we tested ten eco-evolutionary hypotheses proposed to explain the evolution of primate handedness and the emergence of human right-handedness. Our results indicate that none of the hypotheses fully explain patterns of MHI or MABSHI across anthropoids, including humans. Nevertheless, when humans are included in the analysis, certain covariates, particularly brain size and locomotion, show significant effects. These findings are often interpreted as supporting some of the tested hypotheses. However, when humans are excluded, these associations largely disappear, suggesting that such traits may have shaped human handedness but are not general predictors across other anthropoids. Among non-human anthropoids, the most consistent predictor of handedness strength (MABSHI) is terrestriality, which is associated with weaker hand preferences. Model comparisons further show that many of the tested hypotheses receive comparable support, highlighting the need to consider alternative explanations for patterns of lateralisation across the clade. Importantly, our analyses robustly confirm that humans are evolutionary outliers in both handedness direction and strength (observed MHI=0.76 vs. predicted=0.29; observed MABSHI=0.94 vs. predicted=0.73), suggesting the influence of uniquely strong selective pressures on these traits. Together, our findings provide new insights into the evolutionary determinants of handedness in anthropoids and underscore the singular nature of human lateralisation.

This work was funded by a Leverhulme Trust Research Leadership Award to CV (RL-2019-012).

Poster Presentation Number 122, Session 2, Friday 14:00 - 15:30

## Principal components analysis is inaccurate for Plio-Pleistocene hominin systematics

Levi Y. Raskin<sup>1</sup>, Bárbara D. Bitarello<sup>2</sup>, Maja Šešelj<sup>3</sup>, John Huelsenbeck<sup>1</sup>

1 - Department of Integrative Biology, University of California, Berkeley · 2 - Department of Biology, Bryn Mawr College · 3 - Department of Anthropology, Bryn Mawr College

Principal Components Analysis (PCA) is a widely applied statistical technique. It reduces multivariate data into sets of orthogonally constrained vectors that explain decreasing proportions of the dataset's variation. In paleoanthropology, PCA is commonly used to support arguments that certain fossils fall within or near a clade's morphospace. Implicitly or explicitly, this practice equates proximity in PC space to relatedness. The assumption that PCA recovers the phylogenetic structure of the dataset (and thus can be used to make systematic claims) has not been explored.

Here, we test the utility of PCA for hominin systematic arguments. First, we inferred the posterior distribution for the hominin phylogenetic tree using a prominent character matrix of Plio-Pleistocene hominins using Bayesian Markov Chain Monte Carlo. We sampled 1,000 trees from the posterior distribution to provide reasonable backbone trees. For each backbone tree, we first simulated character matrices in R under Brownian motion, the most widely used null model for morphological evolution. Through this sampling and simulation, we are able to construct data with known phylogenetic structure and specified generative parameters. We varied the number of traits in each dataset and simulated those traits under several single-rate conditions, where all traits had the same rate, as well as variable rate conditions, where each trait had a rate drawn from a gamma distribution. We also simulated varying proportions of conflicting phylogenetic signals, a known problem in the hominin fossil record. On each simulated dataset, we conducted a PCA and, using the Euclidean distances in PC space between observations, inferred a test tree using neighbor-joining (NJ). The distance calculation and NJ algorithm approximate how PCA-informed systematics is practiced in the literature: proximity in PCA space translates to less evolutionary distance between the two points. Finally, we compared these NJ test trees against the original backbone topology. The median NJ test tree across all test conditions requires four subtree pruning and regrafting moves to transform it into its backbone tree, indicating substantial discordance between PCA and the underlying phylogenetic structure. Only 0.076% of test trees inferred from PC1 and PC2 across all test conditions were identical to the original backbone tree and 2.4% of test trees inferred from all PC axes across all test conditions were identical. We repeated the same analysis and found consistent results when using Mahalanobis distance instead of Euclidean distances.

We performed a similar but empirical analysis on the original character matrix used to infer the hominin phylogenetic tree posterior distribution. We used Probabilistic PCA to account for missing data in the original character matrix and inferred a NJ test tree based on PC space Euclidean distances. We then compared this test tree against 100,000 trees sampled from our posterior distribution and found that none are identical to the PCA-derived tree. We find that PCA is unlikely to recover phylogenetic structure under a wide variety of simulated conditions and in an empirical dataset. Therefore, PCA should not be used to inform systematic arguments in Plio-Pleistocene hominins, and any systematic arguments reliant on proximity in PC space should be reevaluated.

Poster Presentation Number 124, Session 2, Friday 14:00 - 15:30

## Using ZooMS to compare Neanderthal subsistence strategies and cannibalistic practices across three French Middle Palaeolithic sites

Pauline Raymond<sup>1</sup>, Karen Ruebens<sup>2</sup>, Geoff Smith<sup>2</sup>, Sandrine Costamagno<sup>3</sup>, Isabelle Crevecoeur<sup>4</sup>, Luc Doyon<sup>4</sup>, Alan Mann<sup>5</sup>, Bruno Maureille<sup>4</sup>, Jean-Jacques Hublin<sup>1</sup>

1 - Paleoanthropology Chair, CIRB, Collège de France, PSL University, CNRS, INSERM, Paris, France · 2 - Archaeological Proteomics lab, University of Reading, Whiteknights, Reading, UK · 3 - UMR 5608, TRACES, CNRS, University of Toulouse Jean Jaurès, Toulouse, France · 4 - UMR 5199, PACEA, CNRS, MC, University of Bordeaux, Pessac, France · 5 - Department of Anthropology, Princeton University, NJ, USA

Neanderthal subsistence strategies have shown some variability over time and space, including isolated instances of cannibalism. This latter behavior is supported by comparable cutmarks and impacts resulting from bone fracture on both animal and human remains at Paleolithic sites [1]. This study presents my final PhD results integrating ZooMS, zooarchaeology, and taphonomy to refine interpretations of Neanderthal cannibalism.

Morphologically unidentifiable bone fragments were analysed from three Neanderthal sites in France where cannibalism was previously proposed: Abri Moula (Ardèche; n=1196) [2] dated to MIS 5, Les Pradelles (Charente; n=1139) [3] dated to the end of MIS 4, and Tourtoirac (Dordogne; n=181) [4] not dated yet. The occupation of Abri Moula occurred in a temperate environment dominated by red deer, whereas reindeer were the dominant taxon in the cold environment occupations at Les Pradelles and Tourtoirac.

Excellent preservation of collagen type I at all sites allowed for a high proportion of new ZooMS identifications including various faunal taxa and 57 new Neanderthal remains (48 at Abri Moula, 5 at Les Pradelles and 4 at Tourtoirac). ZooMS assemblages exhibit fewer human modifications, likely due to small fragment size (ca. 2-6 cm). However, butchery traces—including cutmarks and marrow extraction fractures—were recorded on both human and faunal specimens. At Abri Moula, ZooMS-identified red deer and human remains exhibit differing proportions of human modifications; however, when integrated with morphologically identified specimens, the data suggest more comparable modification patterns between the two groups. At Les Pradelles, variabilities in treatment may reflect specialised reindeer hunting, with variable human modifications across taxa potentially indicating taxon-specific butchery adaptations.

Identifying the skeletal element of the ZooMS fragments can also enhance skeletal profiles and reveal differences in the treatment of body elements [5]. At Les Pradelles, this would notably contribute to understanding the virtual absence of human long bone extremities. In Mousterian cannibalistic contexts, human cranial fragments often relatively outnumber those of medium size game (mostly deer), possibly reflecting differences in body part transport or treatment. At Abri Moula, human cranial remains were identified in high proportions morphologically (28%) and with ZooMS (10%), supporting the hypothesis of an intense fragmentation, potentially to collect the brain.

A comparison of the ZooMS and morphological faunal composition shows significant variability with an increase of bovids and decrease of deer in the ZooMS assemblages. At Les Pradelles, it reflects a higher representation of bovid spongy elements, possibly due to differential carcass fragmentation. ZooMS also confirms the presence of carnivores at Les Pradelles and Abri Moula, though they are less represented in the ZooMS dataset compared to morphology. Smaller taxa, such as birds, were also identified at Tourtoirac and Abri Moula.

Overall, at all three sites the ZooMS data confirm Neanderthal cannibalism practices, while offering more detailed insights into its variability and context. The notion of “similar butchery treatment” between fauna and humans, used to discuss cannibalism, proves complex to assess, varying across sites and taxa. Our ZooMS analysis refines our understanding of butchery practices and highlights specificities in human cranium processing. This study also demonstrates the power of applying a multidisciplinary approach to enhance our understanding of existing museum collections to achieve novel perspectives on complex behaviors like Neanderthal cannibalistic activities.

This PhD project is funded by the Labex MemoLife grant. We thank the regional archeology service (SRA) of the Auvergne-Rhône-Alpes region and the Museum of Soyons (Ardèche) for giving us access to the Abri Moula collection. We also thank the SRA of the Nouvelle-Aquitaine region for allowing us to study Les Pradelles and Tourtoirac collections. We also thank Nicolas Vanderesse (PACEA, UMR 5199, University of Bordeaux) for the micro-CT scans of the bones.

References: [1] Bello, S.M., 2024. The archaeology of cannibalism: a review of the taphonomic traits associated with survival and ritualistic cannibalism. *Journal of Archaeological Method and Theory*. 32. [2] Defleur, A., White, T., Valensi, P., Slimak, L., Crégut-Bonnouire, E., 1999. Neanderthal cannibalism at Moula-Guercy, Ardèche, France. *Science*. 286, 128–131. [3] Maureille B., Mann A., Beauval C., Bordes J.-G., Bourguignon L., Costamagno S., Couchoud I., Fauquignon J., Garralda M.D., Geigl E.-M., Grün R., Guibert P., Lacrampe-Cuyaubère Fr., Laroulandie V., Marquet J.-Cl., Meignen L., Mussini C., Rendu W., Royer A., Seguin G., Texier J.-P., 2010. Les Pradelles à Marillac-le-Franc (Charente). *Fouilles 2001-2007: nouveaux résultats et synthèse*. In: Buisson-Catil, J., Primault, J., (Eds.), *Préhistoire entre Vienne et Charente. Hommes et sociétés du Paléolithique*. Association des publications chauvinoises, XXXVIII, Chauvigny, p. 145-162. [4] Crevecoeur, I., Armand, D., Beauval, C., Bosq, M., Dugas, P., Laroulandie, V., Michel, A., Pubert, É., Rosso, D., Royer, A., Rufa Bonache, A., Vaissie, E., Vigier, É., Vignoles, A.L., Villeneuve, Q., Doyon, L., 2024. Découverte de restes humains néandertaliens à l'abri Tourtoirac (Dordogne). *Bulletins et Mémoires de la Société d'Anthropologie de Paris*. 36, S21. [5] Smith, G.M., Ruebens, K., Sinet-Mathiot, V., Welker, F., 2024. Towards a deeper integration of ZooMS and zooarchaeology at Palaeolithic sites: current challenges and future directions. *PaleoAnthropology*. 2024.

Podium Presentation, Session 4, Friday 08:30 – 10:30

## Reevaluating Plio-Pleistocene stone knapping techniques through contemporary stone tool makers

Jonathan S. Reeves<sup>1,2,3</sup>, Matthew J. Douglass<sup>3,4,5</sup>, Christine E. Haney<sup>4</sup>, Lydia Luncz<sup>3</sup>, Bernard A. Wood<sup>2</sup>, Michael Moroto Lomalinga<sup>6</sup>, Benjamin Davies<sup>7</sup>, Emmanuel K. Ndiema<sup>8</sup>

1 - ICAREHB, Universidade do Algarve, Faro, Portugal · 2 - Center of the Advanced Study of Human Paleobiology, Anthropology Department, George Washington University, Washington DC, USA · 3 - Technological Primates Research Group, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 4 - College of Agricultural Sciences and Natural Resources and Agricultural Research Division, University of Nebraska-Lincoln, NE, USA · 5 - Agricultural Research Division, University of Nebraska-Lincoln, NE, USA · 6 - Community Member, Ileret, Marsabit County, Kenya · 7 - Environmental Studies Program, Tufts University, MA, USA · 8 - Department of Earth Sciences, National Museums of Kenya, Nairobi, Kenya

The capacity to make and use cutting tools from stone is a defining trait of the human lineage [1]. Their widespread preservation allows us to reconstruct hominin behaviour from the late Pliocene onward. There is a long-standing consensus that direct free-hand percussion, the act of striking a rock held in one hand with a hammerstone held by the other, was the technique most often used by Early Stone Age hominins to produce simple cutting tools [2]. Direct free-hand percussion has, thus, profoundly influenced our view of hominin evolution. Its influence is emphasized by the sheer number of experimental studies that investigate hominin behavior through the replication of cutting tools using the free-hand technique [3]. As a result, the actions associated with direct-free hand percussion condition our perception of the specific anatomical features, brain functions, social learning mechanisms, and species of hominins capable of ancient tool production [4]. However, the primary association between the free-hand technique with core and flake tools is seldom assessed even though other techniques (e.g. bipolar) are recognized [5].

Here, we evaluate the longstanding association between direct free-hand percussion and the production of sharp-edged flakes through an ethnoarchaeological study of modern stone tool makers. The Daasanach pastoralist community of northern Kenya maintains a tradition of core and flake technology for a variety of cutting tasks, providing an opportunity to document techniques used to produce informal cutting tools. Our study shows that, despite its assumed importance to hominin tool making, direct free-hand percussion was almost never employed by the Daasanach. Instead, tool makers used a range of techniques, including throwing, passive hammer, bipolar, and more, to create sharp cutting edges. Nevertheless, a technological analysis reveals that the lithics created by this diversity of techniques still fall well within the range of core and flake technology made by Plio-Pleistocene hominins. In the absence of behavioral observations, the lithics created by the Daasanach would be primarily associated with free-hand percussion under the current consensus. These findings challenge the link between Plio-Pleistocene lithic technology and the behaviours that are often implicitly associated with it.

By placing these results within the broader context of archaeological research, we argue that the predominant focus on free-hand percussion is due to historical precedent and is overemphasized in reconstructions of hominin behaviour. Furthermore, ancient tool makers likely employed a diverse range of biomechanical actions beyond free-hand percussion, expanding the range of anatomical traits considered adequate for stone tool making. As a result, we call for a critical reassessment of how stone tool production techniques shape our understanding of broader hominin behavioral, cognitive, and anatomical evolution.

We would like to thank the National Science Foundation and Max Planck Society for supporting this research.

References: [1] Antón, S.C., Potts, R., Aiello, L.C., 2014. Evolution of early *Homo*: An integrated biological perspective. *Science*. 345, 1236828. [2] Plummer, T.W., Finestone, E.M., 2018. Archaeological sites from 2.6 - 2.0 Ma: Toward a deeper understanding of the Early Oldowan. In: Schwartz, J.H. (Ed.) *Rethinking Human Evolution*, MIT Press, Cambridge, pp. 267-296. [3] Williams-Hatala, E.M., Hatala, K.G., Key, A., Dunmore, C.J., Kasper, M., Gordon, M., Kivell, T.L., 2020. Kinetics of stone tool production among novice and expert tool makers. *American Journal of Physical Anthropology*. 174, 714–727. [4] Roche, H., Blumenshine, R.J., Shea, J.J., 2009. Origins and Adaptations of Early Homo: What Archeology Tells Us. In: Grine, F.E., Fleagle, J.G., Leakey, R.E. (Eds.) *The First Humans – Origin and Early Evolution of the Genus*: Springer Netherlands Dordrecht, pp. 135–147. [5] Putt, S.S., 2015. The origins of stone tool reduction and the transition to knapping: An experimental approach. *Journal of Archaeological Science: Reports*. 2, 51–60.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## A revised chronology for the Middle Pleistocene sedimentary sequence of Florisbad, Free State, South Africa: implications for the age of the early *Homo sapiens* remains

Mailys Richard<sup>1,2</sup>, Beatrice Bin<sup>1,3</sup>, Will Archer<sup>4,5,6</sup> Michael B. Toffolo<sup>1,3</sup>

1 - Archéosciences Bordeaux, UMR 6034 CNRS-Bordeaux Montaigne University, Pessac, France · 2 - Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Tübingen, Germany · 3 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Burgos, Spain · 4 - National Museum Bloemfontein, Bloemfontein, South Africa · 4 - Max Planck Partner Group, Department of Archaeology and Anthropology, National Museum, Bloemfontein, South Africa · 5 - Florisbad Quaternary Research Station, National Museum, Bloemfontein, South Africa · 6 - Department of Geology, University of the Free State, Bloemfontein, South Africa

The spring site of Florisbad, located in the central interior of South Africa, is known for the discovery of the partial cranium of a human by T.F. Dreyer in 1932 [1], including parts of the frontal, maxillae and parietal bones, as well as a tooth. First classified as *Homo helmei*, an attribution to early *Homo sapiens* was later proposed [2]. The stratigraphic context of the hominin remains is complex, since they were recovered from a spring vent that cut vertically through the sedimentary units, which also contained faunal remains that may represent a carnivore accumulation, considering the marks on both faunal and human remains.

In the 1990s, the tooth has been the subject of a direct dating study using combined electron spin resonance and uranium-series (ESR/U-series) and an age of  $259 \pm 35$  ka was proposed; the sediment was dated using optically stimulated luminescence (OSL) [3]. The validity of this age has been recently questioned on methodological grounds [4]. In 2023, a new chronological study was undertaken in order to apply recently developed protocols on both quartz (conventional OSL and thermally transferred OSL, TT-OSL) and feldspars (post-infrared infrared stimulated luminescence, pIRIR<sub>290</sub>). The sampling focused on the Dreyer section, where the “Peat I” and the “Green sand” are visible, and previously dated by OSL to  $281 \pm 73$  ka and  $157 \pm 21$ ka, respectively [3]. Three sediment samples were taken for luminescence dating from unit O (Early MSA, sample FLB1) and N (Early MSA, sample FLB2), which corresponds to the base and the top of “Peat I” respectively, and from unit M (MSA, sample FLB3) that is part of the “Green sand” [5]. According to the description of Dreyer, the spring vent cut through “Peat I” and was sealed by the “Green sand”, which means that the human remains would be younger than “Peat I” and older than the “Green sand” [5].

Here we applied three different protocols (OSL, TT-OSL and pIRIR<sub>290</sub>) on the most representative grain size from each layer and conducted multigrain analyses on the 4-11 µm grain size fraction from the “Peat I” and both multi- and single-grain analyses on the 100-140 µm grain size fraction from the “Green sand”. Our results suggest that the three dated sedimentary units have been deposited between Marine Isotopic Stages (MIS) 8 and 6, i.e., between ca. 300 ka and 145 ka. Overall, the age results are in good agreement between the different protocols, especially the OSL and the pIRIR<sub>290</sub>, for which dose recovery tests yielded ratios of  $1 \pm 10\%$ . However, the TT-OSL results tend to give older estimates that can be explained by the hard-to-bleach properties of this signal, which may only give a maximum age estimate to the dated layers. We will discuss the implications of these new ages for the reconstruction of the sedimentary processes of the Middle Pleistocene layers of Florisbad, and the chronology of the cranium, that stands out as the oldest remains of *H. sapiens* in southern Africa.

References: [1] Dreyer, T.F., 1935. A human skull from Florisbad, Orange Free State, with a note on the endocranial cast, by CU Ariens Kappers. Proc Koninklijke Akad Wetenschappen te Amsterdam. 38, 3-12. [2] Grün, R., Stringer, C., 2023. Direct dating of human fossils and the ever-changing story of human evolution. Quaternary Science Reviews. 322, 108379. [3] Grün, R., Brink, J.S., Spooner, N.A., Taylor, L., Stringer, C.B., Franciscus, R.G., Murray, A.S., 1996. Direct dating of Florisbad hominid. Nature. 382, 500-501. [4] Berger, L., Hawks, J., 2023. Revisiting the age of the Florisbad hominin material. Homo. 74, 55-60. [5] Kuman, K., Inbar, M., Clarke, R.J., 1999. Palaeoenvironments and Cultural Sequence of the Florisbad Middle Stone Age Hominid Site, South Africa. Journal of Archaeological Science. 26, 1409-1425.

Poster Presentation Number 125, Session 2, Friday 14:00 - 15:30

## Relationships between femoral entheses and locomotion in great apes: implications for fossil hominid locomotor behaviours

Noam Rio<sup>1</sup>, Franck Guy<sup>1</sup>, Victoria Anne Lockwood<sup>1</sup>, Zoé Nowicki<sup>1</sup>, Laurent Pallas<sup>1,2,4</sup>, Alicia Blasi Toccaceli<sup>1,3</sup>, Guillaume Daver<sup>1</sup>

1 - PALEVOPRIM, CNRS, Université de Poitiers (86000), France · 2 - Histoire Naturelle de l'Homme Préhistorique (HNHP), CNRS-MNHN-UPVD, Musée de l'Homme, Paris (75), France · 3 - Department of Anatomy, Midwestern University, AZ, USA · 4 - Kyoto University, Graduate School of Science, Laboratory of Physical Anthropology, Kyoto (606-8502) Japan

Inferring the locomotor behaviour in extinct hominids has long been a challenging task due to the high diversity and preservation issues of these fossil taxa. This is especially true for the earliest hominins, whose poorly preserved postcranial skeletons restrict comparisons to their femora, which has hindered our ability to investigate how bipedalism emerged in the group. Yet, despite these preservation issues, fossil hominid femora exhibit the entheses of numerous hip and knee muscles. Because entheses organs tend to dissipate the mechanical stress generated by muscle contraction and associated tensile forces [1], we would expect that they provide relevant indicators of repetitive muscle use, and thus potentially informative for behavioural interpretations.

However, although descriptions of muscle entheses - both qualitative and quantitative - are plethora in the palaeontological scientific literature, the issue of their functional significance has been questioned, suggesting that other parameters could have been much more influential [2]. More recently, methodological advances confirmed that entheses morphologies of synergetic muscle groups are influenced by activity even if they also vary according to age and sex [3]. This study led to the implementation of a new 3D method (V.E.R.A. or Validated Entheses-based Reconstruction of Activity) that allows for measuring and comparing synergetic muscle groups rather than entheses considered independently, as has been done previously [4]. Therefore, using both extant and extinct hominoid femora, we adapted the V.E.R.A. method to compare the entheses surfaces of each joint complex, focusing on the muscle groups of the hip and knee joints.

We analysed the femoral entheses of 71 individuals, including 23 *Homo sapiens*, 8 *Pan paniscus*, 14 *Pan troglodytes*, 15 *Gorilla* sp., and 11 *Pongo* sp.. All specimens are adults, ideally of wild caught origin and non-pathological. Besides, 14 fossil hominoids including Miocene taxa and Mio-Pliopleistocene hominins from Europe and Africa are included in the analysis. To make relevant comparisons, entheses surfaces were normalized using diaphyseal surfaces. Body mass is estimated using previous work [5].

Our first results show differences in entheses patterns across taxa that can be explained by locomotor behaviours even if phylogenetic constraints cannot be discarded as well. *Homo sapiens* shows a unique combination of entheses morphologies, especially for the hip and knee. *Pongo* clearly differs from the other Great Apes likely due to its high degree of suspension and associated flexible hips. However, whereas *Gorilla* and *Pan* share the same entheses patterns at both the hip and knee, they differ when entheses surfaces are weighted by the body mass, hence suggesting potential phylogenetic effect. Despite taphonomic issues that render several entheses unexploitable—particularly those from the diaphysis—our preliminary results indicate that the stem hominoids (e.g., *Ekembo nyanzae*) and stem hominids (e.g., *Hispanopithecus*) of our sample exhibit markedly different entheses patterns of the hip compared to all extant taxa. This observation may reflect the retention of primitive features in their entheses morphology, indicating that their hominoid-like affinities are less clear-cut than traditionally assumed.

This study represents a preliminary attempt to compare femoral entheses of synergetic muscle groups in extant and extinct hominids using the three-dimensional analytical method V.E.R.A.. Although still under development, this method opens new perspectives for its application to other anatomical regions of the postcranial skeleton in great apes and is expected to provide new insights into the emergence of hominin bipedalism.

Funding was provided by the région Nouvelle Aquitaine (COVAROS, AAPR 2024A-2024-32945810) and PALEVOPRIM. This work has further benefited from the many insightful and constructive discussions held within the framework of the International Research Network “Bipedal equilibrium” (CNRS-INEE GDRI0870). I thank the curators and staff who granted access to the osteological collections of the following institutions: the Royal Museum for Central Africa (E. Gillissen, W. Coudyzer); the Museum für Naturkunde, Berlin (C. Funk); the National Museum of Natural History; and the Musée de l'Homme, Paris (M. Friess, V. Labordes, A. Fort, L. Huet), and the Kyoto university (M. Nakatsukasa).

References: [1] Shaw, H.M., Benjamin, M., 2007. Structure–function relationships of entheses in relation to mechanical load and exercise. *Scandinavian Journal of Medicine & Science in Sports*. 17, 303–315. [2] Williams-Hatala, E.M., Hatala, K.G., Hiles, S., Rabey, K.N., 2016. Morphology of muscle attachment sites in the modern human hand does not reflect muscle architecture. *Scientific Reports*. 6. [3] Karakostis, F.A., Jeffery, N., Harvati, K., 2019. Experimental proof that multivariate patterns among muscle attachments (entheses) can reflect repetitive muscle use. *Scientific Reports*. 9. [4] Karakostis, F.A., Harvati, K., 2021. New horizons in reconstructing past human behavior: Introducing the “Tübingen University Validated Entheses-based Reconstruction of Activity” method. *Evolutionary Anthropology: Issues, News, and Reviews*. 30, 185–198. [5] Ruff, C.B., 2002. Long bone articular and diaphyseal structure in Old World monkeys and apes. II: Estimation of body mass. *American Journal of Physical Anthropology*. 120, 16–37.

Podium Presentation, Session 1, Thursday 09:20 – 11:00

## **Apprenticeship, expertise, and the origins of cognitive complexity in Palaeolithic Art**

**Olivia Rivero<sup>1</sup>, María Soledad Beato<sup>1</sup>, Miguel García-Bustos<sup>1</sup>, Mar Suarez<sup>2</sup>, Alicia Alvarez-Martinez<sup>1</sup>, Ana María Mateo-Pellitero<sup>1</sup>, Xabier Eguilleor-Carmona<sup>1</sup>, Javier Eseverri<sup>1</sup>**

1 - Faculty of Geography and History, University of Salamanca, Spain · 2 - Faculty of Psychology, University of Salamanca, Spain

The study of Palaeolithic art has long focused on its symbolic, cultural, and aesthetic dimensions. However, recent advances in cognitive archaeology invite new approaches to understanding the minds behind the images. This research explores the hypothesis that evidence of apprenticeship and artistic expertise can be documented in Palaeolithic parietal and portable art and can reveal key aspects of early human cognition, including the development of individual visuomotor skills, active learning, and cultural transmission.

This research integrates archaeology and experimental psychology and archaeology, operating under the premise that the neurological architecture of Anatomically Modern Humans has remained largely stable since the Upper Palaeolithic. Methodologically, the study employs high-resolution imaging, 3D modelling, and formal stylistic analysis across a selection of decorated sites and artefacts from Upper Paleolithic of Western Europe. It also integrates theoretical models from cognitive archaeology and expertise research to interpret the archaeological record as evidence of embodied learning. Through psychometric testing, eye-tracking, and drawing and engraving experimental tasks monitored by motion-sensing gloves, this work compares the performance of modern experts in visual arts and archaeology and non-experts when faced with challenges of visualisation and production of Palaeolithic art.

Results indicate that expertise in the visual arts correlates with enhanced spatial abilities and distinctive memory-based drawing strategies. Both groups, however, face similar technical difficulties when engaging engraving tasks using Palaeolithic techniques, suggesting that such practices would have required specialised training—patterns of which may be traceable in the archaeological record through evidence of learning and skill development.

This interdisciplinary approach offers a new framework for evaluating the cognitive demands of Palaeolithic art production, including motor planning, visual abstraction, and the embodiment of technique. It also engages broader questions concerning the social contexts in which these cognitive capacities evolved, particularly the role of teaching, apprenticeship, and knowledge transmission in early symbolic communities. By bridging archaeological evidence with models of embodied cognition and expertise acquisition, this study contributes new perspectives on the cognitive and cultural foundations of Upper Palaeolithic artistic expression.

This work has been funded by the research project "Creation and perception in Anatomically Modern Humans: analysis of the biological, cognitive and social skills linked to the production of Palaeolithic art (ArtMindHuman) Project PID2021-125166OB-I00 funded by MCIN/ AEI /10.13039/501100011033/ and by ERDF A way of making Europe, PI: O. Rivero.

Poster Presentation Number 126, Session 2, Friday 14:00 - 15:30

## Upper third molar crown outlines in Middle Pleistocene fossils from southeastern Europe

Carolyn Röding<sup>1</sup>, Mirjana Roksandic<sup>2,3</sup>, Dimitris S. Kostopoulos<sup>4</sup>, Chris Stringer<sup>5</sup>, Constantin Doukas<sup>6</sup>, Heike Scherf<sup>1</sup>, Katerina Harvati<sup>1,7</sup>

1 - Palaeoanthropology, Institute for Archaeological Sciences and Senckenberg Centre for Human Evolution and Palaeoenvironment, Eberhard Karls University of Tübingen, Tübingen, Germany · 2 - Department of Anthropology, University of Winnipeg, Winnipeg, MB, Canada · 3 - Department of Anthropology, University of Manitoba, Winnipeg, Canada · 4 - Museum of Geology - Palaeontology, School of Geology, Aristotle University of Thessaloniki, Thessaloniki, Greece · 5 - Centre for Human Evolution Research, The Natural History Museum, London, UK · 6 - Department of Geology, National and Kapodistrian University of Athens, Greece · 7 - DFG Centre for Advanced Studies 'Words, Bones, Genes, Tools', Eberhard Karls University of Tübingen, Tübingen, Germany

Recent years have brought important advances in our understanding of the Pleistocene record of southeastern Europe, due to both new fieldwork and re-analyses of old materials (e.g., [1-3]). The latter includes the enigmatic isolated left upper third molar from the Megalopolis basin, Greece. We previously suggested that this surface find might date to the Middle Pleistocene and belong to the Neanderthal lineage [4]. However, our sample in that analysis lacked important comparative specimens. Recently, our team acquired a new micro Computer Tomography (CT) scan of the Petralona cranium, Greece, enabling the inclusion of this important specimen in our analysis. In parallel, the material from Velika Balanica material, Serbia, was published [3] and could also be included. As a result, our study is the first to directly compare dental morphology of multiple Middle Pleistocene individuals from Southeastern Europe.

We employ a crown outline analysis to place the Megalopolis molar, the better preserved right upper third molar from Petralona and Velika Balanica BH-2 in a comparative framework of 48 individuals, ranging from *Homo erectus* to recent *Homo sapiens*. The crown outline analysis provides a framework in which teeth can be analyzed independently of their shape, presence of the dental root and, to a certain degree, occlusal wear. Furthermore, the method is robust to the inclusion of CT scans of high-resolution dental casts, which maximizes the available sample [4].

Principal component analyses of shape- and form-space and overall crown outline shape based on Procrustes distances support our previous attribution of the Megalopolis molar to the Neanderthal lineage. Contrary to expectations, it did not group with either Petralona or the BH-2 individual. The upper third molar from Petralona best matches our Neanderthal sample in the principal component analyses, while its overall shape is closest to the *Homo erectus* molar Sangiran 7-17. In contrast, Velika Balanica BH-2 does not show a clear affinity to any of our samples and the three molars closest in overall shape include one recent *Homo sapiens* from Oceania, NN33 from the Neanderthal type site, Germany, and the Middle Pleistocene molar PN17 from Pontnewydd, Wales. The PN17 UM3 plots intermediate between Petralona and the relatively small Steinheim UM3, which plots close to the Holocene and Pleistocene *Homo sapiens* means in form space.

In summary, the three UM3s from Southeastern Europe reflect the overall picture of great variation in crown outline shape and size observed in our Middle Pleistocene sample. This may be in part due to the nature of upper third molars, which are generally considered to be highly variable (e.g., [5]). Our *Homo sapiens* and Neanderthal samples reflect this only with regard to outline shape. In contrast, outline size tends to be larger in Neanderthals than *Homo sapiens* leading to a partial separation of these groups in form-space. Our study is a first step in integrating diverse Pleistocene fossils from southeastern Europe into a common comparative framework to gain a better understanding of their taxonomic affinities and variation.

This research was supported by the European Research Council (ERC CoG no. 724703; ERC AdG no. 101019659) and the German Research Foundation (DFG FOR 2237). The research of CS is supported by the Calleva Foundation and the Human Origins Research Fund. We thank all curators and collaborators for their help and access to materials. The research of MR is supported by the Social Sciences and Humanities Research Council of Canada (SSHRC) Partnership Grant (895-2024-1005).

References: [1] Harvati, K., Röding, C., Bosman, A.M., Karakostas, F.A., Grün, R., Stringer, C., Karkanas, P., Thompson, N.C., Koutoulidis, V., Mouloupoulos, L.A., Gorgoulis, V.G., Kouloukoussa, M., 2019. Apidima Cave fossils provide earliest evidence of *Homo sapiens* in Eurasia. *Nature*. 571, 500–504. [2] Panagopoulou, E., Tourloukis, V., Thompson, N., Konidaris, G., Athanassiou, A., Giusti, D., Tsartidou, G., Karkanas, P., Harvati, K., 2018. The Lower Palaeolithic site of Marathousa 1, Megalopolis, Greece: Overview of the evidence. *Quaternary International*. 497, 33–46. [3] Roksandic, M., Radović, P., Lindal, J., Mihailović, D., 2022. Early Neanderthals in contact: The Chibanian (Middle Pleistocene) hominin dentition from Velika Balanica Cave, Southern Serbia. *Journal of Human Evolution*. 166, 103175. [4] Röding, C., Zastrow, J., Scherf, H., Doukas, C., Harvati, K., 2021. Crown outline analysis of the hominin upper third molar from the Megalopolis Basin, Peloponnese, Greece. In: Reyes-Centeno, H., Harvati, K. (Eds.), *Ancient Connections*, Kerns Verlag, Tübingen, p. 13–36. [5] Macho, G.A., Moggi-Cecchi, J., 1992. Reduction of maxillary molars in *Homo sapiens sapiens*: A different perspective. *American Journal of Physical Anthropology*. 87, 151–159.

Poster Presentation Number 127, Session 2, Friday 14:00 - 15:30

## Feeding ecology of *Macaca* (Cercopithecidae, Primates) from the Middle Pleistocene Megalopolis Basin (Greece): a combined approach using dental microwear and enamel isotopic biogeochemistry

Effrosyni Roditi<sup>1</sup>, Christos A. Plastiras<sup>2,3</sup>, George E. Konidaris<sup>1,3</sup>, Hervé Bocherens<sup>4,5</sup>, Gildas Merceron<sup>6</sup>, Athanassios Athanassiou<sup>7</sup>, Eleni Panagopoulou<sup>7</sup>, Panagiotis Karkanas<sup>8</sup>, Katerina Harvati<sup>1,5</sup>

1 - Paleoanthropology, Institute for Archaeological Sciences, Department of Geosciences, Eberhard Karls University of Tübingen, Tübingen, Germany · 2 - Leverhulme Centre for Human Evolutionary Studies, Department of Archaeology and Anthropology, University of Cambridge, Cambridge, United Kingdom · 3 - School of Geology, Aristotle University of Thessaloniki, Thessaloniki, Greece · 4 - Biogeology, Department of Geosciences, Eberhard Karls University of Tübingen, Tübingen, Germany · 5 - Senckenberg Centre for Human Evolution and Palaeoenvironment at the University of Tübingen, Tübingen, Germany · 6 - Laboratoire PALEVOPRIM, UMR 7262 CNRS & University of Poitiers, France · 7 - Hellenic Ministry of Culture, Ephorate of Paleoanthropology–Speleology, Athens, Greece · 8 - M.H. Wiener Laboratory for Archaeological Science, American School of Classical Studies at Athens, Greece

Despite the wide geographical distribution of the monkey *Macaca* in western Eurasia and its long evolutionary history from the Late Miocene to the Late Pleistocene [1], our knowledge on specific aspects of its remarkable ecological success remains relatively limited. In Greece, the fossil record of macaques was until recently extremely scarce, known from only a few isolated dental specimens from the Early Pleistocene. However, recent fieldwork in the Megalopolis Basin (Peloponnese) has yielded two additional *Macaca* specimens, an almost complete mandible (the most complete fossil European macaque mandible known to date) and an isolated upper molar, from the Middle Pleistocene fossil sites Marathousa 1 (MAR-1, ca. 430 ka, MIS 12) and Kyparissia 4 (KYP-4, ca. 700 ka), respectively [2,3].

In this study, we investigate the feeding ecology of the two Middle Pleistocene macaque individuals from the Megalopolis Basin by combining evidence from enamel isotopic biogeochemistry and dental microwear texture analysis. Bulk enamel samples were obtained from the lower third molar of the MAR-1 mandible and from the KYP-4 upper first molar. Stable carbon ( $\delta^{13}\text{C}$ ) and oxygen ( $\delta^{18}\text{O}$ ) isotope ratios were measured on the carbonate component of tooth enamel and compared to the isotopic composition of coeval herbivores from the two sites ([4] and ongoing study). For the microwear analysis, data were extracted on both Phase I (shearing) and Phase II (crushing) facets. The Megalopolis specimens were then compared with available texture data of fossil macaques from Europe and extant macaque species (see [5]).

The results of the microwear analysis show that the individual from KYP-4 potentially fed on relatively harder food resources such as nuts, fruits, and seeds, whereas the individual from MAR-1 consumed softer and/or tougher food resources. Data from stable carbon isotopes complement the study and support habitat distinction, demonstrating lower  $\delta^{13}\text{C}$  values and a more densely forested environment for the KYP-4 macaque and higher  $\delta^{13}\text{C}$  values for the MAR-1 specimen, which likely foraged in open woodland. A  $\text{C}_3$  diet is evident for both specimens; however, the MAR-1 macaque yielded slightly higher  $\delta^{13}\text{C}$  values compared to the mixed-feeding elephant and hippopotamus individuals from the same site, possibly indicating a bulk diet with a higher component of heterotrophic plant parts (e.g., fruits, seeds, or bark). The specimen from KYP-4 displayed generally lower  $\delta^{13}\text{C}$  values, consistent with a bulk diet richer in foliage or understory plants. Differences observed in oxygen isotope ratios between macaques and other herbivores (hippopotamus, elephant, giant deer, rhinoceros, and horse) could be associated with the arboreal habits of the former.

Our multi-approach method to reconstruct long-term and short-term dietary preferences underline the ecological flexibility of *Macaca* during the Middle Pleistocene. The distinct dietary signals between the two individuals could indicate they had access to diverse food resources in the basin. Our findings suggest that the presence and persistence of macaques in the area, even through multiple glacial or stadial periods, were potentially facilitated by the spatial availability of a wide array of resources, which further supports the interpretation of the Megalopolis Basin as part of the Southern European refugium for macaque populations, as well as hominins and other fauna and flora, in Europe.

This research was supported by the ERC-CoG-724703 ("CROSSROADS") awarded to K. Harvati (University of Tübingen). Excavation at Marathousa 1 was conducted under the auspices of the Ephorate of Palaeoanthropology–Speleology, Hellenic Ministry of Culture. Megalopolis Palaeoenvironmental Project (MEGAPAL) is a collaboration between the Ephorate of Palaeoanthropology–Speleology and the American School of Classical Studies at Athens, under the direction of Dr. Panagopoulou, Dr. Karkanas, and Prof. Dr. Harvati and funded by the European Research Council (CoG 724703). K.H., G.E.K., and E.R. were also supported by the DFG Project no. 463225251 ("MEGALOPOLIS"). E.R. and K.H. are also supported by ERC-AdG-101019659. We thank P. Tung (Senckenberg HEP, University of Tübingen) for his technical and scientific support in stable isotope analysis. The DMTA on the extant and extinct sample were conducted by C.A.P. and G.M. as part of his doctorate studies and financed by Greece and the European Union (European Social Fund) through the Operational Program 'Human Resources Development, Education and Lifelong Learning' in the context of the project 'Strengthening Human Resources Research Potential via Doctorate Research' (MIS-5000432), implemented by the State Scholarships Foundation (IKY); the Eiffel Excellence Scholarship Programme of the French Ministry of Foreign and European Affairs; and the Diet Scratches Project (ANR-17CE27-0002-01; PI: G. Merceron).

References: [1] Elton, S., O'Regan, H.J., 2014. Macaques at the margins: the biogeography and extinction of *Macaca sylvanus* in Europe. *Quaternary Science Reviews*. 96, 117–130. [2] Konidaris, G.E., Athanassiou, A., Panagopoulou, E., Harvati, K., 2022. First record of *Macaca* (Cercopithecidae, Primates) in the Middle Pleistocene of Greece. *Journal of Human Evolution*. 162, 103104. [3] Konidaris, G.E., Athanassiou, A., Panagopoulou, E., Karkanas, P., Harvati, K., in press. Fossil macaques (Cercopithecidae, Primates) from the Middle Pleistocene of the Megalopolis Basin (Greece) with description of a new specimen from Kyparissia 4. In: Harvati, K., Ioannidou, M. (Eds.), *Human Evolution at the CROSSROADS: Research in Greece and beyond*, Tübingen University Press, Tübingen. [4] Roditi, E., Bocherens, H., Konidaris, G.E., Athanassiou, A., Tourloukis, V., Karkanas, P., Panagopoulou, E., Harvati, K., 2024. Life-history of *Palaeoloxodon antiquus* reveals Middle Pleistocene glacial refugium in

the Megalopolis basin, Greece. Scientific Reports. 14. [5] Plastiras, C.A., Thiery, G., Guy, F., Alba, D.M., Nishimura, T., Kostopoulos, D.S., Merceron, G., 2023. Investigating the dietary niches of fossil Plio-Pleistocene European macaques: The case of *Macaca majori* Azzaroli, 1946 from Sardinia. Journal of Human Evolution. 185, 103454.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## Recombination of technological modules: the *tranchet* blow in Tabun Cave, Israel, and its implication for cumulative culture and cognitive evolution in the Middle Pleistocene

Tamar Rosenberg-Yefet<sup>1</sup>, Uri Hertz<sup>2,3</sup>, Ron Shimelmitz<sup>1</sup>

1 - School of Archaeology and Maritime Cultures, Zinman Institute of Archaeology, University of Haifa, Israel · 2 - Department of Cognitive Sciences, University of Haifa, Israel · 3 - The Institute of Information Processing and Decision Making, University of Haifa, Israel

One of the key factors driving the accelerated complexity of human culture—and marking a major turning point in human evolution—is the growing capacity for cumulative culture, rooted in advanced forms of social learning. Notably, the evolution of cumulative culture and complex technologies does not arise solely from the improvement of individual tools or techniques, but from the ability to recombine different technological modules. This process of recombination, in which distinct procedures are integrated in novel ways, fosters the emergence of new ideas and innovations (e.g. [1]). While the integration of simpler procedures such as the exploitation of conchoidal fractures or striking platform preparation into new forms of stone tool technologies appears as early as the beginning of stone tools, we aim to highlight the integration of multiple procedures into a cohesive operational unit central to the design and function of later technologies [2]. The emergence of the latter might represent a new benchmark in human capability, accelerating both the pace and scale of innovations. Cognitive psychology research portrays that complex problem-solving is often achieved by breaking down a challenge into smaller, manageable subtasks. Solutions to these subtasks can then be flexibly recombined and applied to a range of broader problems through mental simulation—a process involving the imagination and internal rehearsal of scenarios, challenges, and solutions prior to their execution [3]. We, accordingly, argue that identifying the onset of modular recombination can greatly contribute to our research of human cognitive evolution.

While the chronological depth of modular recombination in lithic technologies remains uncertain, this presentation introduces one of the earliest known examples from the Middle Pleistocene, focusing on the site of Tabun and the transition between the Acheulian and Acheulo-Yabrudian complexes—dated earlier to 400 ka and excavated by A. Ronen [4]. Within the lithic assemblages of the relevant layers at Tabun, we identified three groups of artifacts that repeatedly employ a technological module known as the ‘*tranchet* blow.’ Although the term may imply a simple action, the technique is in fact more complex, requiring prior preparation, specific working orientation and tool adjustment [5]. We thus examine the hypothesis that the ‘*tranchet* blow’, originally associated with handaxe shaping in the Late Acheulean, functioned as a transferable module, in which through a process of recombination, the hominins at Tabun applied this technological module to new contexts. Specifically, we explore how the ‘*tranchet* blow’ module was integrated into the reduction sequences of three distinct artifact types: Adlun burins, Nahr Ibrahim cores-on-flakes, and scrapers with lateral edge rejuvenation. Towards this goal we present a techno-morphological study of these three artifact groups, alongside an examination of *tranchet* spalls produced during the process.

The results highlight how this technological module was systematically adapted and recombined in innovative ways that diverge from its original function in handaxe production. While additional examples from the Levant and other regions are likely to be identified, the presence of the example studied here—dated to the first half of the Middle Pleistocene—correlates well with recent studies highlighting this period as a major step in technological complexity [1]. Together, these findings provide further evidence for the development of human cognition and cumulative culture during this timeframe.

References: [1] Paige, J., Perreault, C., 2024. 3.3 million years of stone tool complexity suggests that cumulative culture began during the Middle Pleistocene. *Proceedings of the National Academy of Sciences*. 121, e2319175121. [2] Youn, H., Strumsky, D., Bettencourt, L.M., Lobo, J., 2015. Invention as a combinatorial process: Evidence from US patents. *Journal of the Royal Society, Interface* 12, 20150272. [3] Laland, K., Seed, A., 2021. Understanding human cognitive uniqueness. *Annual Review of Psychology*. 72, 689–716. [4] Ronen, A., Gisis, I., Tchernikov, I., 2011. The Mugharan tradition reconsidered. In: Le Tensorer, J.-M., Jagher, R., Otte, M. (Eds.), *The Lower and Middle Paleolithic in the Middle East and Neighboring Regions*. ERAUL 126, 121–130. [5] Prévost, M., Centi, L., Zaidner, Y., 2022. The use of the lateral *tranchet* blow technique at Nesher Ramla (Israel): A new cultural marker in the Levantine Middle Paleolithic? *Quaternary International*. 624, 128–147.

Poster Presentation Number 128, Session 2, Friday 14:00 - 15:30

### 3D analysis of dental morphological variability in Papionini primates from the Plio-Pleistocene of Eastern and Southern Africa

Berta Ruesca-Bonet<sup>1</sup>, Ferran Estebaranz-Sánchez<sup>2</sup>, Albert E. Dyowe-Roig<sup>1</sup>, Luís Hidalgo-Trujillo<sup>1,2</sup>, Ignacio De la Torre<sup>3</sup>, Jackson Njau<sup>4</sup>, Yala B. Mendoza<sup>5</sup>, Laura M. Martínez<sup>1,2</sup>

1 - Departament de Biologia Evolutiva, Ecologia i CCAA, Facultat de Biologia, Universitat de Barcelona, Spain · 2 - Institut d'Arqueologia de la Universitat de Barcelona, Spain · 3 - CSIC-Spanish National Research Council. Madrid, Spain · 4 - Indiana University, USA · 5 - Escuela Nacional de Ciencias Forenses (ENaCIF), Universidad Nacional Autónoma de México

The Papionini lineage diverged from the rest of cercopithecoidea species approximately at 11.5 Ma during the Miocene [1]. Papionini primates were highly abundant throughout the Pliocene and Pleistocene in Africa, where a regional environmental changes and interspecific competition likely influenced their radiation. In eastern Africa, extinct Papionini specimens are found in a wide variety of habitats, including forest, woodlands, and grasslands. In contrast, in southern Africa, the evolution of the cercopithecoidea primates appears to be associated with the expansion of grasslands and open habitats during the Pleistocene [2]. Extant Papionini also occupy a broad range of ecological niches as a result of a great adaptability and evolutionary success, ranging from the closed forests and open woodlands, to savannas exploited by *Papio*, and the highland ecosystems of the Ethiopian Plateau inhabited by *Theropithecus gelada*.

The aim of this study is to analyze the dental morphology of the lower third molar (M3) of extinct Papionini specimens from several eastern and southern Plio-Pleistocene sites, in order to assess interspecific variability and infer morphological similarities and dietary adaptations. This study has implications for interpreting hominin evolution, as fossil records of both Papionini and Hominini frequently co-occur at the same sites, suggesting possible niche partitioning with analogous evolutionary trends.

The sample consists in dental cast of lower M3s from three extant genera (*Theropithecus gelada*, *Papio* sp. and *Macaca sylvanus*) and several extinct taxa with a time span between 4 to 0,5 Ma (*Dinopithecus*, *Gorgopithecus*, *Theropithecus oswaldi*, *Parapapio* sp and *Papio* sp) obtained from the originals curated at several institutions. All the teeth were scanned with a white light scanner Shining® and 3D meshes were processed using Meshlab and Geomagic software. Processing included isolating molars, mesh orientation, and cropping to the lowest point on the occlusal basin. A total of 11 anatomical landmarks were placed using 3D Slicer to analyze shape variation in both extant and extinct specimens. A General Procrustes Analysis (GPA) was performed to study morphological variability among taxa. The effect of allometry was evaluated, and residuals from the regression of Procrustes Distances on centroid size were used to perform a Principal Component Analysis (PCA).

The results indicate that extant *Macaca* shows significant morphological differences compared to extant *Papio* and *Theropithecus*. *Parapapio* specimens present morphological similarities with extinct *Theropithecus* and *Papio*. In contrast, extant *Papio* and *Theropithecus* differ from their extinct counterparts, suggesting that M3 morphology significantly changed throughout their evolutionary history.

This research has received funding from MCIU/AEI/10.13039/501100011033 PID2023-148818NB-I00 to LMM and funding of European Research Council-Advanced Grants (BICAHEFID, No. 832980).

References: [1] Tosi, A.J., Detwiler, K.M., Disotell, T.R., 2005. X-chromosomal window into the evolutionary history of the guenons (Primates: Cercopithecoidea). *Molecular Phylogenetics and Evolution*. 36, 58–66. [2] Elton, S., 2007. Environmental Correlates of the Cercopithecoidea Radiations. *Folia Primatologica*. 78, 344–364.

Podium Presentation, Session 7, Saturday 08:30 – 10:30

## Gait in Dmanisi differed from African *Homo erectus*

Christopher B. Ruff<sup>1</sup>, Kristian Carlson<sup>2</sup>, David Lordkipanidze<sup>3</sup>, Tea Jashashvili<sup>2,3,4</sup>

1 - Center for Functional Anatomy and Evolution, Johns Hopkins University School of Medicine, Baltimore, USA · 2 - Division of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, Los Angeles, USA · 3 - Georgia National Museum, Tbilisi, Georgia · 4 - Department of Radiology, Keck School of Medicine, University of Southern California, Los Angeles, USA

Terrestrial bipedal gait in early *Homo* (except for *H. habilis* s.s.) has been considered to be essentially similar to that of modern humans. The earliest evidence for this pattern is based on East African *H. erectus* or “*erectus*-like” postcrania, dating back to ca. 1.9–2.0 Ma [1]. However, there are hints that locomotion may not have been completely modern in all early *Homo*, including in the Dmanisi sample (1.77 Ma) [2–4]. Previous analyses of the Dmanisi lower limb remains have focused primarily on the lower leg and foot. However, proximal femoral morphology has also been shown to be informative regarding hip joint loadings and gait patterns among hominins [5]. Here we assess proximal femoral structural characteristics in the adult Dmanisi femur (D4167) in relation to modern humans, other early *Homo*, australopiths, and nonhuman hominoids.

CT scans were taken of the Dmanisi femur at the Department of Computed Tomography, Tbilisi Central Clinic Hospital. Femoral head breadth; neck height, breadth, and biomechanical length; neck-shaft angle; and superior and inferior cortical thicknesses at mid-neck and the base of the neck, were measured in ImageJ using established protocols [5]. Cross-sectional geometric properties of the diaphysis at a standardized subtrochanteric level were obtained using MomentMacro. Comparative data were available from previous studies.

Results show a mixture of primitive and derived features in the Dmanisi proximal femur, indicating some similarities to but also a number of differences from those of *H. erectus* and modern humans. Similar to all early hominin femora, D4167 has a long femoral neck and low neck-shaft angle, increasing gluteal abductor mechanical advantage, which is structurally advantageous if biacetabular breadth was wide, as it is in all known australopiths and early *Homo*. Like other early *Homo* (except *H. habilis* s.s.), femoral to humeral shaft strength is completely modern, indicating a full commitment to terrestrial bipedalism. Distribution of cortical bone in the femoral neck is similar to that of modern humans, which is another indication of a lack of any significant arboreal behavior. However, in other respects the Dmanisi proximal femur is more similar to australopiths than to *H. erectus* or modern humans. It has a small femoral head relative to knee breadth, indicating a reduction in hip joint reaction force. Its femoral neck is superoinferiorly expanded relative to femoral head breadth, indicative of relatively increased S-I bending loads. Its proximal shaft is not mediolaterally expanded as in *H. erectus*, but is more like that of australopiths. All of these features imply a reduction and different orientation of hip joint and gluteal abductor forces in Dmanisi compared to *H. erectus*, more similar to those of australopiths and possibly resulting from a more lateral translation of the body center of mass during the stance phase of gait [5].

Together with evidence from limb length proportions and structure of the distal lower limb, the current results confirm that the Dmanisi individual was a fully committed terrestrial biped. However, its terrestrial gait mechanics likely differed in subtle but significant ways from those of *H. erectus* and modern humans. Since the earliest evidence for the *H. erectus*/modern human gait pattern occurs in East Africa well prior to the occupation of the Dmanisi site, this implies that either a) the inhabitants of Dmanisi represent an early (pre-2.0 Ma) out-of-Africa dispersal, occurring prior to the development of typical *H. erectus* postcranial morphology and gait mechanics, or b) Dmanisi was derived from a different contemporaneous non-*erectus* lineage in Africa. It should be noted that either scenario is not inconsistent with the single-species consensus at Dmanisi.

We would like to thank Dr. Nikoloz Sanishvili from the Department of Computed Tomography at Tbilisi Central Clinic Hospital for his assistance with scanning the Dmanisi specimens. We also wish to honor the memory of Gocha Kiladze.

References: [1] Day, M.H., 1984. The postcranial remains of *Homo erectus* from Africa, Asia, and possibly Europe. *Courier Forschungsinstitut Senckenberg*, 69, 113–121. [2] Lordkipanidze, D., Jashashvili, T., Vekua, A., de León, M.S.P., Zollikofer, C.P.E., Rightmire, G.P., Pontzer, H., Ferrer, R., Oms, O., Tappen, M., Bukhsianidze, M., Agusti, J., Kahlke, R., Kiladze, G., Martínez-Navarro, B., Mouskhelishvili, A., Nioradze, M., Rook, L., 2007. Postcranial evidence from early *Homo* from Dmanisi, Georgia. *Nature*, 449, 305–310. [3] Pontzer, H., Rolian, C., Rightmire, G.P., Jashashvili, T., Ponce de León, M.S., Lordkipanidze, D., Zollikofer, C.P.E., 2010. Locomotor anatomy and biomechanics of the Dmanisi hominins. *Journal of Human Evolution*, 58, 492–504. [4] Dowdeswell, M.R., Jashashvili, T., Patel, B.A., Lebrun, R., Susman, R.L., Lordkipanidze, D., Carlson, K.J., 2017. Adaptation to bipedal gait and fifth metatarsal structural properties in *Australopithecus*, *Paranthropus*, and *Homo*. *Comptes Rendus Palevol*, 16, 585–599. [5] Ruff, C.B., Higgins, R., 2013. Femoral neck structure and function in early hominins. *American Journal of Physical Anthropology*, 150, 512–525.

Poster Presentation Number 129, Session 2, Friday 14:00 - 15:30

## New evidence of late hunter-gatherer interactions with large carnivores in the central Levant

**Gabriele Russo<sup>1</sup>, Roberto Rozzi<sup>2,3</sup>, Majid Aljaber Abo Fakher<sup>1</sup>, Maya Haïdar-Boustani<sup>4</sup>, Yamandú H. Hilbert<sup>1</sup>, Sireen El Zaatari<sup>1</sup>**

1- Paleoanthropology, Senckenberg Centre for Human Evolution and Palaeoenvironment, Eberhard Karls University of Tübingen, Tübingen, Germany · 2- Zentralmagazin Naturwissenschaftlicher Sammlungen, Martin Luther University Halle-Wittenberg, Halle (Saale), Germany · 3 - Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Berlin, Germany · 4 - Musée de Préhistoire libanaise, Université Saint-Joseph de Beyrouth, Lebanon

It was 135 years ago when the Antelias Cave in central Lebanon was excavated for the first time [1], unveiling a rich assemblage of lithic tools, faunal remains, and human fossils. The faunal material recovered during these early investigations is considered the first zooarchaeologically studied and published collection from the entire Levant [2,3]. Part of this collection was donated to the Geological-palaeontological Collections of the Martin Luther University Halle-Wittenberg in Germany, where it remained largely overlooked until very recently. Its value is especially significant given that the original site has since been destroyed.

A renewed analysis of the faunal remains, together with direct radiocarbon dating of the associated human remains, has placed the site between 15,000 and 11,000 years ago. This period corresponds to the final phase of the Epipaleolithic (EP) in the Levant, a pivotal moment at the end of the Pleistocene marked by major cultural transitions. These transformations laid the groundwork for the technological, economic, and social developments that ultimately led to the rise of sedentary agricultural societies [4]. In spite of the many studies focusing on the Levantine late EP archaeology, an important aspect remains largely understudied: the interaction between large carnivores and human communities during this period. To date, there are only four recorded instances, all from the southern Levant, presenting evidence of human interaction with large carnivores. These involve isolated bones of leopards (*Panthera pardus*), bears (*Ursus arctos syriacus*), and lions (*Panthera leo*), some of which bear signs of human modification [5].

Within this broader context, the Antelias faunal collection stands out by providing the first clear evidence of large carnivore exploitation in the central Levant. It also offers some of the earliest and most substantial material from a single site across the region. Among the findings are cut marks on leopard and bear bones, indicating active processing by humans. The data suggest intentional use of specific body parts, including the exploitation of bear pelts and the possible symbolic or cultural use of leopard teeth.

Interactions with dangerous carnivores were probably infrequent and primarily understood as responses to competition over territory or as incidental encounters. However, evidence from Antelias, points to a more complex relationship in which large carnivores played a notable and culturally meaningful role in the lives of the last hunter-gatherer communities of the Levant.

This research is funded by the European Research Council under the European Union's Horizon 2020 research and innovation program, grant agreement number 101001889 (REVIVE). The REVIVE project is being conducted in close collaboration with the Lebanese Directorate General of Antiquities, Ministry of Culture.

References: [1] Zumoffen, G., 1900. La Phénicie avant les phéniciens: l'âge de la pierre. Beyrouth: Imprimerie Catholique, Beirut. [2] von Fritsch, F., 1895. Die funde des Herrn Pater Gottfried Zumoffen in den höhlen am fusse des Libanon. In: Abhandlungen Der Naturforschenden Gesellschaft Zu Halle 1893-1895. Band XIX, Halle, pp. 41–81. [3] Garrard, A.N., 1980. Man-Animal-Plant Relationships during the Upper Pleistocene and Early Holocene. Darwin College University of Cambridge, Cambridge. [4] Maher, L.A., Richter, T., Stock, J.T., 2012. The Pre-Natufian Epipaleolithic: Long-term Behavioral Trends in the Levant. *Evolutionary Anthropology*. 21, 69–81. [5] Shimelmitz, R., Reshef, H., Nativ, A., Marom, N., 2022. Large predator hunting and its interpretation: Leopards, bears and lions in the archaeological record of the Southern Levant. *Cambridge Archaeological Journal*. 1–20.

Poster Presentation Number 130, Session 2, Friday 14:00 - 15:30

## Paleoecological implications of variation in dental morphology in extant and fossil *Theropithecus*

Eliott Sabourin<sup>1</sup>, Antoine Souron<sup>2</sup>, Jean-Renaud Boissier<sup>3</sup>, Lazarus Kgasi<sup>4</sup>, Margot Louail<sup>5,6</sup>, Gildas Merceron<sup>1</sup>, Blade Engda Redae<sup>7</sup>, Xavier Valentin<sup>1</sup>, Bernhard Zipfel<sup>8</sup>, Axelle Elise Colette Walker<sup>1</sup>

1 - PALEVOPRIM - UMR 7262, University of Poitiers · 2 - PACEA - UMR 5199, University of Bordeaux · 3 - French Centre for Ethiopian Studies, CNRS & Ministry of Europe and Foreign Affairs, Addis Ababa · 4 - Ditsong National Museum of Natural History, Pretoria · 5 - The American School of Prehistoric Research, Harvard University, Cambridge · 6 - Department of Human Evolutionary Biology, Harvard University, Cambridge · 7 - Institute of Human Origins, School of Human Evolution and Social Change (SHESC), Arizona State University · 8 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg

*Theropithecus gelada* is the only extant species of a genus that was once more diverse and widely distributed. They display peculiar postcranial and dental anatomical features. Their high crowned and mesio-distally pinched cuspids allow them to feed on tough food such as grasses but also, during the dry season, on underground storage organs (USOs) that can represent another challenge to process [1]. Although their distribution is currently limited to the Ethiopian Highlands, this was not the case during the Plio-Pleistocene when *Theropithecus* was distributed much more widely and commonly associated with hominins such as *Homo* or *Paranthropus*. During this period, global cooling and aridification took place in Africa and they are associated with the spread of grasslands [2]. Among primates, including hominins and cercopithecoids, these environmental changes were accompanied by dietary changes [3]. Some of these taxa are in fact suspected to have increased their consumption of C4 herbaceous plants, or of USOs. *Theropithecus* can be a valuable model to understand these changes.

Isotopic and microwear analyses [1-5] found that extant and fossil members overall share the same resources (either C3 or C4 grasses), with slight differences among some fossil populations such as Ahl al Oughlam specimens or Shungura specimens from the members B, D and E. These specimens exhibit microwear patterns consistent with a more frequent consumption of hard and brittle foods like seeds than geladas. Our objective is to characterize the dental morphology among *Theropithecus* and observe its variation in time and in space. Variation in cheek tooth shape does not provide information on the same time span as microwear or isotopes and can further be linked to a more efficient capacity to fragment a certain type of food. To characterize it, we employed 3D dental topography which uses different variables, corresponding to one or several morphological aspects of the tooth shape, such as exposition, relief or sharpness.

Our sample is composed of lower and upper first and second molars of *Theropithecus* covering a large wear spectrum (Meikle's grades 1 to 7). It comprises extant *Theropithecus gelada* mostly from the Guassa area (n=38) and fossil specimens from Ahl al Oughlam (Morocco, n=6), Shungura (Ethiopia, members C to G, n=30), Swartkrans (Member 1, n=11) and Makapansgat (members 3 and 4, n=3) (South Africa), spanning a temporal range from 2.9 Ma to 1.89 Ma.

Our results demonstrate significant variation among sites and taxa, particularly in the sharpness of the molar. Specimens from Ahl al Oughlam and Shungura (Member D) exhibit lower sharpness than the extant *Theropithecus gelada* or specimens from South Africa. Tooth wear also plays a part on the functional surface of the tooth, as heavily worn teeth show restricted surface participating in the tooth sharpness. Although we do not exclude a phylogenetic signal, our results seem to align with microwear data [4,5] and raise questions about ecological diversity or local and long-term adaptations within the genus.

These observations give us insights into morphological adaptations of *Theropithecus* to specific environments, and the way it reacts to ecological constraints within a context of environmental changes. Moreover, they contribute to a refined understanding of the paleoecological context in which genera like *Homo* and *Paranthropus* emerged and diversified.

We would like to express our sincere gratitude to the Ethiopian Heritage Authority, the OGRE and IORE missions, the University of the Witwatersrand, the Ditsong National Museum of Natural History, the Prehistoric Program of Casablanca, the National Institute of Archaeology and Heritage Sciences (INSAP), and the Ministry of Youth, Culture and Communication / Department of Culture of the Kingdom of Morocco. We also thank the French Ministry for Europe and Foreign Affairs and the Archimedes Laboratory of Excellence (Programme Investir l'Avenir ANR-11-LABX-0032-01 – Origins Project) for the access of the specimens. We are particularly grateful to Franck Guy, Vincent Lazzari and Amélie Beaudet for their contributions, and Kristin Krueger, Lesla Hluko, and Raquel Hernando Santamaria for the access to the wear coding system. Special thanks go to Zinash Abebe Lemma, curator of the Addis collections, as well as to the Guassa Gelada Research Project (Peter Fashing, Nga Nguyen, and Vivek Venkataraman), and to Chalachew Seyoum. We thank Nicolas Vanderesse for his work on the CT scans. This research was supported by funding from the Leakey Foundation, the GPR Human Past program, and the PALEVOPRIM laboratory.

References: [1] Souron, A., 2018. Morphology, diet, and stable carbon isotopes: On the diet of *Theropithecus* and some limits of uniformitarianism in paleoecology. *American Journal of Physical Anthropology*. 166, 261–267. [2] Caley, T., Souron, A., Uno, K.T., Macho, G.A., 2025. Climate and human evolution: Insights from marine records. *Annual Review of Marine Science*. 17, 23–53. [3] Levin, N.E., Haile-Selassie, Y., Frost, S.R., Saylor, B.Z., 2015. Dietary change among hominins and cercopithecids in Ethiopia during the early Pliocene. *Proceedings of the National Academy of Sciences*. 112, 12304–12309. [4] Martin, F., Plastiras, C.-A., Merceron, G., Souron, A., Boissier, J.-R., 2018. Dietary niches of terrestrial cercopithecines from the Plio-Pleistocene Shungura Formation, Ethiopia: evidence from Dental Microwear Texture Analysis. *Scientific Reports*. 8. [5] Louail, M., Geraads, D., Daujeard, C., Gallotti, R., Lefèvre, D., Mohib, A., Raynal, J.-P., Merceron, G., Under review. A close-up at the paleoecology of the most western gelada relatives: insights from dental microwear texture analysis.

Poster Presentation Number 131, Session 2, Friday 14:00 - 15:30

## Ad hominin: the rise and fall of Neanderthal rhetoric in American politics

Peter Sahlins<sup>1</sup>

1 - History Department, University of California, Berkeley

This paper, part of a forthcoming book on the myth, rhetoric, and science of Neanderthals in modern society [1], focuses on the origins, use, and decline of the “Neanderthal” slur in the United States from Hitler to Trump. Since the discovery of a partial skullcap in the Neander valley in 1856, Neanderthals have mostly gotten a bad rap, beginning with later nineteenth century paleoanthropology’s construction of Neanderthals as a brutish, violent, and stupid human ancestor. In the early twentieth century, thanks in part to the paleontologist Marcellin Boule, Neanderthals were expelled from human ancestry, crystallizing their ape-like identity as a lesser human double [2]. It was precisely at this moment that the English-language turned the name of an extinct Paleolithic hominin into an insult. Beginning in the 1920s, but especially after World War II, “Neanderthal” came to signify persons, ideas, and institutions that were considered conservative and reactionary, but also sexist, racist, and out-of-touch with modern values. In the twentieth century, “Neanderthal” became a stalwart rhetorical figure of liberal and progressive politics at the very moment when their inherited, negative reputation as an inferior and brutish, “knuckle-dragging cave man” came under attack. My paper explores the tensions and mutual influences of the shifting paleoanthropological understanding of Neanderthals and popular cultural images of the Paleolithic hominin focusing on the period from the 1940s onward.

The relations between science and popular culture were hardly straightforward in this period and can be considered as a dialogue in three acts. In the first, from the end of World War II to the 1980s, human origins research largely rehabilitated Neanderthals, while in the same decades, their reputation as stupid and brutish humans, lacking language and symbolic capacities, was deepened [3]. The heyday of the Neanderthal insult in American politics were the decades after the War during the struggles against racism – using one N-word to criticize those who used the other – and against reactionary politics. The second act lasted from the 1980s to the early twenty-first century: in this period, Neanderthals actually lost standing in the dominant paleoanthropological paradigms that instead celebrated the recent African origins of *Homo sapiens* and especially the “Human” and “Cognitive Revolutions” that attributed to *Sapiens* alone the invention of culture [4]. At the same time, Neanderthal rhetoric came under attack in print and popular culture, and the use of the Neanderthal slur began to disappear – although it would find a renewed vitality in the social movements of feminism and environmentalism in the 1980s. The third act, beginning in the early twenty-first century, witnessed a convergence of scientific and popular cultural ideas in the demythification and rehabilitation of Neanderthals [5]. The slur itself practically disappeared in print and might have gone extinct but for the election of Donald Trump in 2016, who single-handedly restored its usage and even extended its appearance globally. The paper ends with a discussion of the contemporary reputation of Neanderthals in print culture and social media, considering how despite their dramatic rehabilitation in recent years, supported by paleogenomic and archaeological research, the older stereotype still carries significant weight even though it has mostly disappeared from political discourse.

Thanks to Margaret Conkey, David Bell, and Jim Chandler.

References: [1] *Neanderthals Among Us: A Prehistoric Human in the Modern World*, 2026. Oneworld, London. [2] Drell, J.R.R., 2000. Neanderthals: A History of Interpretation. *Oxford Journal of Archaeology* 19, 1–24. [3] Madison, P., 2020. Characterized by Darkness: Reconsidering the Origins of the Brutish Neanderthal. *Journal of the History of Biology* 53, 493–519. [4] Roebroeks, W., Soressi, M., 2016. Neanderthals revised. *Proceedings of the National Academy of Sciences* 113, 6372–6379. [5] Manias, C., Wrangé Sykes, R., Pyne, L., 2025. Shadows in the Mirror: A Discussion on Understandings of Neanderthals and Australopithecines. In: Manias, C. (Ed.), *Palaeontology in Public*. UCL Press, p. 255–286.

Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## Decoding Acheulean skill: experimental and archaeological approaches to hominin cognition

Sol Sánchez-Dehesa Galán<sup>1,2,3</sup>, Olivia Rivero Vilá<sup>1</sup>

1 - MSCA-COFUND USAL4EXCELLENCE, Faculty of Geography and History, University of Salamanca, Spain · 2 - Laboratoire Technologie et Ethnologie des Mondes Préhistoriques, UMR8068, CNRS France · 3 - ICArEHB - Interdisciplinary Center for Archaeology and Evolution of Human Behaviour, Faculdade das Ciências Humanas e Sociais, Universidade do Algarve, Campus de Gambelas, Faro, Portugal

The ability to produce large flakes, the increasing selectivity of raw materials according to specific tasks, and the spatial and temporal fragmentation of large bifacial reduction sequences are some of the technical milestones traditionally used to highlight the more complex organization and greater knapping mastery of Acheulean groups compared to earlier Oldowan toolmakers. However, when examined diachronically, the cognitive complexity of the Acheulean is often assessed through typological or morphological criteria—particularly symmetry and standardization in handaxes—overlooking the wide range of techniques and methods that emerged throughout this period. As a result, discussions on early hominin cognitive evolution are frequently dominated by broad comparisons between “simple flake production”, “handaxe production”, and “prepared core technologies” [1]. Yet, although highly informative, these long-term perspectives of the early stone age material culture results in reducing more than a million years of technological innovation to a single, idealized form: the biface—symmetric in face, profile, and section—presented as the pinnacle of Acheulean knapping skills.

This oversimplification, while useful for addressing certain questions, has significant consequences not only for archaeological interpretation but also from a paleoanthropological perspective. Some of the technological innovations documented in the archaeological record have been suggested to result from the emergence of new, more encephalized hominin species [2]. These hypotheses underscore the importance of integrating technological data into discussions of hominin evolution. Yet the fossil record associated with the Acheulean remains highly fragmentary, and the anatomical characteristics of the individuals responsible for these assemblages are still largely unknown.

Here, we present a new project that aims to refine our understanding of the technological changes that occurred prior to the emergence of our species, and the associated motor and cognitive abilities. Built upon a detailed technological analysis of East African archaeological assemblages, the project dissects reduction sequences to identify the technical challenges and gestural requirements underlying tool production. These insights are then tested through experimental archaeology, applying psychometric assessments, eye-tracking, and electroencephalography to reproduce and measure the cognitive and motor demands of Acheulean gestures and decision-making processes.

Preliminary results on the gestural repertoire visible throughout the Acheulean indicate an increase capacity of evaluating and adjusting interrelated parameters—such as hammerstone mass, gesture speed, and trajectory—through time, and according to different raw materials and goals.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 101034371.

References: [1] Muller, A., Shipton, C., Clarkson, C., 2022. Stone toolmaking difficulty and the evolution of hominin technological skills. *Scientific Reports*. 12. [2] Gallotti, R., Mussi, M., 2017. Two Acheuleans, two humankinds: From 1.5 to 0.85 Ma at Melka Kunture (Upper Awash, Ethiopian highlands). *Journal of Anthropological Sciences*. 95, 137-181.

Poster Presentation Number 132, Session 2, Friday 14:00 - 15:30

## Hominins and bears from Petralona Cave and Sima de los Huesos of Atapuerca

Elena Santos<sup>1,2</sup>, Juan Luis Arsuaga<sup>1,3</sup>, Antonis Bartsiokas<sup>4</sup>

1 - Centro Mixto UCM-ISCIH de Evolución y Comportamiento Humanos, Madrid, Spain · 2 - CENIEH (Centro Nacional de Investigación sobre la Evolución Humana), Burgos, Spain · 3 - Departamento de Geodinámica, Estratigrafía y Paleontología. Fac Geológicas. Universidad Complutense de Madrid, Madrid, Spain · 4 - Department of History and Ethnology, Democritus University of Thrace, Komotini, Greece

The Petralona cave has been the subject of sustained biochronological debate since the mid-1970s, primarily due to the discovery of an isolated human skull lacking a clear archaeological context. Numerous studies have since addressed the site's chronology, although interpretations vary considerably regarding both its absolute age and the composition of the associated faunal assemblages. Within this framework, several paleontological analyses focused on large carnivores have supported a mid-Middle Pleistocene age for the site [1-2]. Luminescence dating from the Sima de los Huesos (SH) site suggests an age around 400 ka BP [3], although the direct dating of cave bears fossils in SH points to an age around 300 ka BP [4].

The human skull from Petralona has traditionally been associated with a faunal assemblage comparable to that linked with the *Ursus deningeri* cranium PEC1002 analyzed in the present study. Therefore, a comparative analysis between the complete *U. deningeri* crania from SH and Petralona may provide valuable insights into the chronology of the fossil assemblage to which both the ursid and the Petralona human remains belong.

Our comparative analysis of the complete *U. deningeri* crania from SH and Petralona (PEC1002) reveals a strong morphological congruence in both exocranial and endocranial traits. These specimens share several derived characteristics—such as overall cranial shape, dental morphology and proportions, a stepped forehead, the shape and position of the frontal sinuses, a thick palate, and the configuration of the basioccipital—as well as primitive features, including a non-pneumatized basioccipital, indicative of an early evolutionary stage within the *U. deningeri* lineage of cave bears. In many respects, both SH99 and PEC1002 exhibit intermediate morphologies between *Ursus arctos* and *Ursus spelaeus*, which is consistent with the expected condition in *U. deningeri*. However, in certain features—such as the anterodorsal cranial profile and the shape of the cribriform plate—PEC1002 appears slightly more primitive than SH99.

Based on the high degree of morphological similarity, it is reasonable to assign PEC1002 to a similar, or potentially earlier, chronological and evolutionary stage relative to the SH specimen. These findings contribute new data to the ongoing biochronological discourse surrounding the faunal assemblages associated with the Petralona human remains.

The Petralona hominin skull is more primitive (i.e., less Neanderthal-like) than the SH human collection. This is consistent with the Petralona bear skull from the chamber where the skull was found being slightly more primitive (i.e., less spelaeoan-like) than the SH bears. Finally, both Petralona and SH hominins are more primitive (i.e., less Neanderthal-like) than the fully Neanderthal skull Apidima 2 (Greece), dated at a minimum age of 160 ka by Bartsiokas et al. [5].

The research of the Atapuerca sites is funded by the Spanish Ministry of Science and Innovation and European Regional Development Fund “ERDF A way of making Europe” (projects PID2021-122355NB-C31 and C33). ES receives funding from the Atapuerca Foundation.

References: [1] Kurtén, B., Poulanos, A.N., 1977. New Stratigraphic and faunal material from Petralona Cave, with special reference to the Carnivora. *Anthropos* 4, 47-130. [2] Rabeder, G., Tsoukala, E., 1990. Morphodynamic analysis of some cave bear teeth from Petralona cave. *Beiträge zur Paläontologie von Österreich* 16, 103-109. [3] Arnold, L.J., Demuro, M., Parés, J.M., Arsuaga, J.L., Aranburu, A., Bermúdez de Castro, J.M., Carbonell, E., 2014. Luminescence dating and palaeomagnetic age constraint on hominins from Sima de los Huesos, Atapuerca, Spain. *Journal of Human Evolution* 67, 85-107. [4] Bischoff, J.L., Fitzpatrick, J.A., León, J., Arsuaga, J.L., Falguères, C., Bahain, J.-J., Bullen, T., 1997. Geology and preliminary dating of the hominin-bearing sedimentary fill of the Sima de los Huesos Chamber, Cueva Mayor of the Sierra de Atapuerca, Burgos, Spain. *Journal of Human Evolution* 33, 129-154. [5] Bartsiokas, A., Arsuaga, J.L., Aubert, M., Grün, R., 2017. U-series dating and classification of the Apidima 2 hominin from Mani Peninsula, Southern Greece. *Journal of Human Evolution* 109, 22-29.

Poster Presentation Number 133, Session 2, Friday 14:00 - 15:30

## Hominin isotopic niche in the Southern Iberian sub-plateau during the late Middle Pleistocene

Paula Sanz-Henche<sup>1</sup>, Darío Fidalgo<sup>2</sup>, Miriam Pérez de los Ríos<sup>1</sup>, Carlos A. Palancar<sup>2</sup>, Sara Díaz Pérez<sup>3</sup>, Josu Aranbarri<sup>4</sup>, Lucía Bermejo<sup>5</sup>, Isidoro Campaña Lozano<sup>6</sup>, Oscar Cambra-Moo<sup>7</sup>, Gabriel Cifuentes-Alcobendas<sup>8,9</sup>, Almudena Estalrich<sup>2</sup>, Anna Rufà<sup>10,11</sup>, Daniel García-Martínez<sup>1,12</sup>

1 - Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 2 - Department of Palaeobiology, Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain · 3 - Institute of Archaeology, University of Wrocław, Wrocław, Poland · 4 - Department of Geography, Prehistory and Archeology, Universidad del País Vasco/Euskal Herriko Unibertsitatea, UPV/EHU · 5 - PATRICIA. Unidad de Investigación y Transferencia en Ciencias del Patrimonio. Universidad de Córdoba, Córdoba, Spain · 6 - Department of Ecology and Geology, Faculty of Sciences, Universidad de Málaga, Spain · 7 - Laboratorio de Poblaciones del Pasado (LAPP), Department of Biology, Faculty of Sciences, Universidad Autónoma de Madrid · 8 - Instituto de Evolución en África, Universidad de Alcalá, Madrid, Spain · 9 - Universidad de Alcalá, Department of History and Philosophy, Madrid, Spain · 10 - Interdisciplinary Center for Archaeology and the Evolution of Human Behaviour (ICArEHB), Universidade do Algarve, Faro, Portugal · 11 - UMR 5199 – De la Préhistoire à l'Actuel: Culture, Environnement et Anthropologie (PACEA), Université Bordeaux, CNRS, MCC, Pessac, France · 12 - Laboratory of Forensic Anthropology, Centre for Functional Ecology, Department of Life Sciences, Universidade de Coimbra, Coimbra, Portugal

The recently discovered late Middle Pleistocene palaeoanthropological site of Ruidera [1] opens a new window to the study of human and ecosystem evolution in the Iberian Peninsula. In particular, the great abundance, good preservation and peculiar diversity of macro-mammals together with the presence of human fossils at this site is remarkable. Along with the human remains, we found numerous individuals of European tahr, deer, horses, lions, leopards, lynxes, wolves, rabbits and birds. In this work, we present a palaeoecological approach using stable isotope analysis ( $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) of enamel in human and macro-mammals of six different taxa, including both herbivores and carnivores.

The aim of this study is to make a first approximation to the type of ecosystem present around this site ca. 300 kyr ago, focusing on the hypothesis that it represents the most arid record in Europe during this period given its latitude. Of particular interest in this study is the comparison of the hominine isotopic niche at Ruidera with other Iberian Middle Pleistocene sites in which stable isotope analysis in tooth enamel have been carried out. Sites considered for the comparative study are: Trinchera Dolina (TD10+TD11) [2], Sima de los Huesos [2,3] and Trinchera Galería (GII+GIII) [2] (Sierra de Atapuerca) and Punta Lucero (Bizkaia) [4]. It is also mentionable that only the taxa of the same genus as that of Ruidera has been selected. Within this framework, the only comparable published data for hominins are the  $\delta^{13}\text{C}$  values from Sima de los Huesos [3].

Preliminary results of the analysis infer a Mediterranean ecosystem for Ruidera, with the most arid environment (most positive  $\delta^{13}\text{C}$  values) recorded in late Middle Pleistocene of the Iberian Peninsula. However, it is not so unexpected given that this is the southernmost site analysed with enamel stable isotopes in Europe with this chronology. In addition, when analysing  $\delta^{18}\text{O}$  values, Ruidera shares a similar range to that of Punta Lucero, but considerable differences with those sites from Sierra de Atapuerca can be observed. The taphonomy and faunal list indicate an environment that favoured the characteristic biases of mountainous areas with a strong influence of accumulation by carnivores.

Focusing on the Iberian Middle Pleistocene hominin, our results of the analysed Ruidera individual suggest a similar isotopic niche to that of the leopards of the same site. The proposed high proteic diet in the hominin from Ruidera would align with the results from some other European Middle Pleistocene sites [5]. Similarly, one of the hominins from Sima de los Huesos shares a similar isotopic niche as the large carnivores, suggesting the exploitation of the same type of resources. This individual could suggest a proteic diet, similar to that also inferred in the Ruidera hominin. Nonetheless, the Sima de los Huesos individual shares  $\delta^{13}\text{C}$  values with *Panthera fossilis*, whereas the Ruidera hominin, with *Panthera pardus*. However, this tendency could possibly not apply to all individuals from Sima de los Huesos, as the other individual analysed has much lower  $\delta^{13}\text{C}$  values, inferring a wider dietary plasticity for this late Middle Pleistocene Iberian hominin population.

Although the obtained results for Ruidera are in line with palynological, taphonomic and palaeontological approaches, the peculiar arid environment inferred stands out, unique among other Iberian or European late Middle Pleistocene sites. The inferred human isotopic niche is consistent with a mainly carnivorous diet, similar to that observed in some of the individuals from the Sima de los Huesos. Even so, we do not rule out the possibility of obtaining a much broader trophic niche range for these hominins in future analyses of more individuals.

We thank Antonio Ruiz Reinos, guard of the house state, for collaboration in the preservation of the archaeo-paleontological heritage in Los Villares. We also want to acknowledge Ignacio Mosqueda (Parque Natural de las Lagunas de Ruidera), Josefa Moreno (Ruidera mayoress), and JCCM for specific permits to carry out the excavation campaigns. This project is funded by the Leakey Foundation project 45148, "Paleoanthropological investigation at Ruidera-Los Villares: Deciphering Middle Pleistocene Enigma in Western Europe," and the PALARQ Foundation project entitled: "Desvelando la Cronología del Pasado Humano: Análisis Multimétodo de Datación en el Yacimiento de Ruidera-Los Villares, Pleistoceno Medio."

Reference: [1] García-Martínez, D., Duval, M., Zhao, J., Feng, Y., Wood, R., Huguët, R., Cifuentes-Alcobendas, G., Palancar, C.A., Moya-Maleno, P.R., 2022. Los Villares locality (Ruidera, Castilla-La Mancha, Spain): a new Middle Pleistocene fossil assemblage from the Southern Iberian Plateau with possible evidence of human activity. *Cuaternario y Geomorfología*. 36, 7–35. [2] García García, N., Feranec, R.S., Arsuaga, J.L., Bermúdez de Castro, J.M., Carbonell, E., 2009. Isotopic analysis of the ecology of herbivores and carnivores from the Middle Pleistocene deposits of the Sierra De Atapuerca, northern Spain. *Journal of Archaeological Science*. 36, 1142–1151. [3] García, N., Feranec, R.S., Passey, B.H., Cerling, T.E., Arsuaga, J.L., 2015. Exploring the potential of laser ablation carbon isotope analysis for examining ecology during the ontogeny of Middle Pleistocene hominins from Sima de los Huesos (Northern Spain). *PLOS ONE*. 10, e0142895. [4] Domingo, L., Rodríguez-Gómez, G., Libano, I., Gómez-Olivencia, A., 2017. New insights into the Middle Pleistocene paleoecology and paleoenvironment of the Northern Iberian Peninsula (Punta Lucero Quarry site, Biscay): A combined approach using mammalian stable isotope analysis and trophic resource availability modeling. *Quaternary Science Reviews*. 169, 243–262. [5] Ecker, M., Bocherens, H., Julien, M.-A., Rivals, F., Raynal, J.-P., Moncel, M.-H., 2013. Middle Pleistocene ecology and Neanderthal subsistence: Insights from stable isotope analyses in Payre (Ardèche, southeastern France). *Journal of Human Evolution*. 65, 363–373.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Reconstruction of two new pelves from the Sima de los Huesos Site (Sierra de Atapuerca, Spain)

Sthella Savall<sup>1,2</sup>, Juan Luis Arsuaga<sup>1,2</sup>

1 - Centro UCM-ISCIH de Investigación sobre Evolución y Comportamiento Humanos, Madrid, España · 2 - Facultad de Ciencias Geológicas, Departamento de Paleontología, Universidad Complutense de Madrid, Madrid, España

The pelvis is a key element for understanding the evolution of the genus *Homo*, as it is directly related to both bipedal locomotion and obstetric capabilities. However, despite its anatomical and functional importance, fossil pelvises are extremely rare in the paleontological record. Only a few relatively complete specimens are known worldwide, such as Kebara 2 (*Homo neanderthalensis*), A.L. 288-1 (“Lucy”, *Australopithecus afarensis*), and Sts 14 (*Australopithecus africanus*). In this context, Pelvis 1 from the Sima de los Huesos (SH) site, dated to the Middle Pleistocene, represents one of the most relevant and complete findings to date [1-3].

In this study, we present two new pelvic reconstructions from the Sima de los Huesos: Pelvis 2 and Pelvis 3. Both were obtained using a combined approach of physical and digital reconstruction, involving molding techniques, 3D scanning, and digital processing. The reconstructions were performed through mirror imaging based on anatomically associated coxal and sacral elements: Coxal II (AT-800) and a sacrum (AT-1005, AT-1234, AT-2721) for Pelvis 2, and Coxal III (AT-3807+AT-3808+AT-3809+AT-3300) with a different sacrum (AT-3711+AT-4200+AT-4350) for Pelvis 3. In both cases, the remains belong to adult individuals, allowing for a robust comparison of pelvic dimensions and regional morphology with the rest of the SH assemblage, with other fossil specimens, and with samples of both modern and archaic *Homo sapiens* populations.

These new pelvises confirm and expand upon the morphological pattern observed in Pelvis 1, characterized by marked robustness, an exceptionally wide bi-iliac breadth, and a long pubis. The craniocaudal thickness of the superior pubic ramus displays an intermediate morphology between that of *Homo sapiens* (thick) and *Homo neanderthalensis* (narrow), suggesting an ancestral condition within the human lineage. Furthermore, the birth canal in these individuals was analyzed in all three planes (inlet, midplane, and outlet), providing valuable insights into pelvic morphology and its potential obstetric functionality.

The addition of these new reconstructions, together with the extensive pelvic remains from Sima de los Huesos, enables a deeper exploration of morphological variability within a Middle Pleistocene population and sheds new light on the evolutionary trajectories that led to modern pelvic morphology.

References [1]: Arsuaga, J.L., Carretero, J.-M., Lorenzo, C., Gómez-Olivencia, A., Pablos, A., Rodríguez, L., García-González, R., Bonmatí, A., Quam, R.M., Pantoja-Pérez, A., Martínez, I., Aranburu, A., Gracia-Téllez, A., Poza-Rey, E., Sala, N., García, N., Alcázar de Velasco, A., Cuenca-Bescós, G., Bermúdez de Castro, J.M., Carbonell, E., 2015. Postcranial morphology of the middle Pleistocene humans from Sima de los Huesos, Spain. *Proceedings of the National Academy of Sciences*. 112, 11524–11529. [2] Arsuaga, J.-L., Lorenzo, C., Carretero, J.-M., Gracia, A., Martínez, I., García, N., Castro, J.-M.B. de, Carbonell, E., 1999. A complete human pelvis from the Middle Pleistocene of Spain. *Nature*. 399, 255–258. [3] Bonmatí, A., Gómez-Olivencia, A., Arsuaga, J.-L., Carretero, J.M., Gracia, A., Martínez, I., Lorenzo, C., Bermúdez de Castro, J.M., Carbonell, E., 2010. Middle Pleistocene lower back and pelvis from an aged human individual from the Sima de los Huesos site, Spain. *Proceedings of the National Academy of Sciences*. 107, 18386–18391.

Poster Presentation Number 134, Session 2, Friday 14:00 - 15:30

## **Fire and the use of fire at the Middle Paleolithic Travertine Site of Weimar-Ehringsdorf - an archaeological and technological perspective**

**Tim Schüler<sup>1</sup>**

<sup>1</sup> -Thuringian State Office for the Preservation of Historical Monuments and Archaeology, Weimar, Germany

The controlled use of fire stands out as a crucial technological and cultural milestone and is widely discussed [1]. The travertine site of Weimar Ehringsdorf offers valuable insights into how early humans, particularly Neanderthals in MIS7, harnessed and utilized fire in their daily lives. Ehringsdorf has a long history of research. September 21, 2025 marks the 100th anniversary of the discovery of the skull calotte EhrH nearby a charcoal layer (Brandschicht). Despite this, there have been few detailed investigations into the use of fire. And that, although the observations during quarrying since 1907 and the excavations from 1953 to 1961 and 2003 to 2020 at Weimar Ehringsdorf have uncovered numerous indications of fire use. Charred bones, ash deposits, and burnt flint are among the primary evidence supporting the hypothesis that fire played a pivotal role in the lives of the site's inhabitants.

In contrast to other travertine sites, such as Bilzingsleben and Taubach, the find layers in Ehringsdorf are predominantly in hard banked travertine. One of the most remarkable aspects of the hard travertine is its ability to reconstruct the surface shortly after the Neanderthals left the settlement site. A disadvantage of the hard travertine is that the documentation of the spatial distribution of burnt bone and other fire features is only possible in exceptional cases. Under these conditions, this study concentrates on detailed profiles and thin sections. But the micromorphology of the travertine is not directly comparable with that of sediments. That's why Micro-XRF was used to better understand the individual components in the thin sections. By examining these slices under a reflected light microscope and a polarizing microscope, it was possible to identify the microstructures and mineral compositions that provide clues about the environmental conditions during the formation of travertine.

The challenge is to find out how long the period between the last human activity and the preservation by travertine was. Including experiments with fire on recent travertine formation sites, first hypotheses are presented. According to the suggested three-step evaluation of the data to investigate the human mastery of fire [2], three classes of fire evidence can be identified for the Ehringsdorf site.

These studies help to reconstruct paleoenvironments, shedding light on the climatic conditions and hydrological processes that influenced the deposition of travertine at sites like Weimar-Ehringsdorf. The results are important for the understanding of fire traces in a complex large-scale travertine site and allow their classification. These are key factors for a better reconstruction of the human activities during MIS7 on this site.

References: [1] Roebroeks, W., MacDonald, K., Scherjon, F., 2021. Establishing Patterns of Early Fire Use in Human Evolution. [2] Stahlschmidt, M.C., Miller, C.E., Ligouis, B., Hambach, U., Goldberg, P., Berna, F., Richter, D., Urban, B., Serangeli, J., Conard, N.J., 2015. On the evidence for human use and control of fire at Schöningen. *Journal of Human Evolution*. 89, 181–201.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Epigenetic signatures of craniofacial evolution: first insights from DNA methylation patterns

Alexandra Schuh<sup>1</sup>, Elena Essel<sup>2</sup>, Tobias Graessle<sup>3</sup>, Carsten Jäger<sup>4,5</sup>, Genevieve Housman<sup>6</sup>, Philipp Gunz<sup>1</sup>

1 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 2 - Department of Evolutionary Genetics, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 3 - Ecology and Emergence of Zoonotic Diseases, Helmholtz Institute for One Health, Helmholtz Centre for Infection Research, Greifswald, Germany · 4 - Department of Neurophysics, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany · 5 - Paul Flechsig Institute - Centre of Neuropathology and Brain Research, University of Leipzig, Leipzig, Germany · 6 - Department of Primate Behavior and Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany

Primate craniofacial morphology shows considerable variation, with humans standing out among great apes despite their close genetic ties. Much of this diversity is now understood to stem from changes in gene expression during development [1]. Yet, the precise role of gene regulation in driving skeletal evolution – both across non-human primates and between extinct hominins and modern humans – remains poorly understood. DNA methylation, a key mechanism of gene regulation, serves as a tissue-specific marker of gene activity in mammals. Recent breakthroughs have enabled the reconstruction of DNA methylation maps from ancient skeletal remains, promising new insights into the regulatory basis of human-specific traits and the morphological divergence between archaic and modern humans [2,3]. Ancient DNA studies typically extract molecular data from dense skeletal elements such as the petrous portion of the temporal bone or dental roots which have optimal biomolecular preservation. However, it remains unclear to what extent methylation patterns from these sources are representative of other craniofacial regions or tissues. Major knowledge gaps persist – especially in musculoskeletal tissues, where gene expression patterns and regulatory interactions are still poorly characterized in human and non-human primates [4]. We lack a clear understanding of how gene regulation varies not only between individuals and species, but also within a single organism across cranial bones derived from different embryonic tissues [5]. These gaps reflect both the logistical challenges of sampling primate skeletal tissues and the technical difficulties of extracting regulatory information from the mineralized bony matrix. Closing these gaps is essential for uncovering the developmental and evolutionary mechanisms underlying craniofacial diversity and for linking regulatory patterns in ancient and modern skeletal remains.

We examined DNA methylation across multiple craniofacial regions (face vs. neurocranium) and tissue types (bone, teeth, and muscle) in two mammalian species: the Barbary macaque (*Macaca sylvanus*) and the wild boar (*Sus scrofa*). For each individual, six tissue samples were collected. Bone cores were extracted using a 40 mm diameter drill, and cortical bone was separated from trabecular bone with sterile scalpels and washed to remove all possible soft tissue. Powder was obtained from hard tissues using a freezer mill. DNA was extracted from all tissues following two different protocols, each adapted to soft and hard tissues, respectively. We use whole-genome bisulfite sequencing to reconstruct genome-wide DNA methylation patterns and generate high-resolution methylation maps across the cranium. These data clarify patterns of gene regulation variation across bones with different embryonic origins (e.g., neural crest-derived facial bones and mesoderm-derived cranial vault), as well as whether elements commonly sampled in archaeogenetic studies accurately represent broader cranial methylation patterns.

Our findings provide essential baseline data on the spatial specificity of gene regulation in the skull, a major gap even in model organisms. By comparing tissues within and across species, we gain new insights into the developmental and evolutionary mechanisms underlying craniofacial diversity. Ultimately, this work improves the anatomical resolution of epigenetic studies, strengthens the link between gene regulation and skeletal morphology, and opens new pathways for exploring the molecular basis of primate and human craniofacial evolution.

We thank Ashley Nagel (Max Planck for Evolutionary Anthropology, Leipzig) and Pauline Fänder (Max Planck for Evolutionary Anthropology, Leipzig) for their help in accessing and preparing the samples.

References: [1] Prud'homme, B., Gompel, N., Carroll, S.B., 2007. Emerging principles of regulatory evolution. *Proceedings of the National Academy of Sciences*. 104, 8605–8612. [2] Gokhman, D., Lavi, E., Prüfer, K., Fraga, M.F., Riancho, J.A., Kelso, J., Pääbo, S., Meshorer, E., Carmel, L., 2014. Reconstructing the DNA Methylation Maps of the Neandertal and the Denisovan. *Science*. 344, 523–527. [3] Gokhman, D., Nissim-Rafinia, M., Agranat-Tamir, L., Housman, G., García-Pérez, R., Lizano, E., Cheronet, O., Mallick, S., Nieves-Colón, M.A., Li, H., Alpaslan-Roodenberg, S., Novak, M., Gu, H., Osinski, J.M., Ferrando-Bernal, M., Gelabert, P., Lipende, I., Mjunga, D., Kondova, I., Bontrop, R., Kullmer, O., Weber, G., Shahar, T., Dvir-Ginzberg, M., Faerman, M., Quillen, E.E., Meissner, A., Lahav, Y., Kandel, L., Liebergall, M., Prada, M.E., Vidal, J.M., Gronostajski, R.M., Stone, A.C., Yakir, B., Lalueza-Fox, C., Pinhasi, R., Reich, D., Marques-Bonet, T., Meshorer, E., Carmel, L., 2020. Differential DNA methylation of vocal and facial anatomy genes in modern humans. *Nature Communications*. 11, 1189. [4] Housman, G., 2024. Advances in skeletal genomics research across tissues and cells. *Current Opinion in Genetics & Development*. 88, 102245. [5] Young, M., Richard, D., Grabowski, M., Auerbach, B.M., de Bakker, B.S., Hagoort, J., Muthuirulan, P., Kharkar, V., Kurki, H.K., Betti, L., Birkenstock, L., Lewton, K.L., Capellini, T.D., 2022. The developmental impacts of natural selection on human pelvic morphology. *Science Advances*. 8, eabq4884.

Poster Presentation Number 135, Session 2, Friday 14:00 - 15:30

## No individual differences in figure recognition and visual attention patterns during the observation of Palaeolithic art

**María Silva-Gago<sup>1</sup>, Marcos García-Díez<sup>2,3</sup>, Emiliano Bruner<sup>4,5</sup>, Luis Martínez<sup>6</sup>, Felipe Criado-Boado<sup>1</sup>**

1 - Instituto de Ciencias del Patrimonio (INCIPIT), CSIC, Santiago de Compostela · 2 - Department of Prehistory, Ancient History and Archaeology, Universidad Complutense, Madrid (UCM) · 3 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Tarragona · 4 - Museo Nacional de Ciencias Naturales (MNCN), CSIC, Madrid · 5 - Reina Sofia Foundation Alzheimer Centre, CIEN Foundation, ISCIII, Madrid · 6 - Instituto de Neurociencias de Alicante (IN), CSIC-UMH, Alicante

Art visual processing is a complex cognitive function that involves perception, attention and decision-making. In particular, Palaeolithic art represents a structured form of graphic communication, intended to be perceived and interpreted by members of the original human group, with the potential for a lasting impact beyond the moment of creation [1]. The first stage of this visual system is characterized by exploration through rapid eye movements, known as saccades, which are produced between small pauses called fixations. These eye movements can be recorded by eye tracking technology and provide insights into attentional patterns and information processing [2]. Moreover, according to active inference models of cognition, eye movements play a key role in minimizing prediction errors generated by the brain through comparisons between perceived input and prior experiences [3]. From this perspective, vision operates as a predictive system that manages both external salience factors and internally generated information.

In this study, we employ eye-tracking to investigate visual perception during the observation of Palaeolithic rock art, focusing on the behavioural and biological mechanisms involved in figure recognition and attentional allocation. Participants were instructed to freely observe a series of photographs of zoomorphic figures from several Cantabrian seaboard caves for a duration of 10 seconds while their eye movements were recorded using a screen-based eye tracker. After finished the observation, participants were asked if they recognised the animals depicted. The areas of greatest visual saliency and therefore likely to attract attention were calculated by graph-based visual saliency (GBVS) computation algorithm. Then, different areas of interest (AOIs) were defined based on these most computed salient locations (saliency AOI), other elements in the cave such as fissures, calcite formations and other changes in the morphology of the support (cave AOI), as well as the depiction. Furthermore, some AOIs were defined based on the main anatomical regions of the figures, namely head, anterior, body and posterior. We computed the dwell time (in milliseconds) relative to the size of each AOI (in pixels) as a measure of fixation density over an area [4]. This variable (relative dwell time, DT\_REL) standardizes the amount of attention directed to each AOI regardless of their size. Our results suggest that attention was predominantly directed to the depicted figures, in particular to their heads, rather than to other elements of the visual field, regardless of whether or not the participant recognised the depicted animal. Even when the animal was not identified, gaze and attention consistently focused on the most informative areas of the panel, indicating that the painting guides visual exploration. Additionally, no significant differences were observed based on participants' gender or prior archaeological and domain-specific knowledge, at least with respect to the variables and depictions employed in this study. In summary, we propose eye tracking as a tool to study the perception of rock art from a cognitive point of view, revealing that the paintings guide the observer and create common patterns of observation which facilitate the identification of the animal depicted [5].

We would like to thank all the XSCAPE team for their help in the development of the experiments and to all the volunteers who participated in the study. MSG is supported by the Spanish Government - MCIN/AEI - and the European Union - Next Generation EU/PRTR (JDC2022-048286-I). This study is also part from XSCAPE Project, founded by the European Research Council (ERC-2020-SyG 95163). EB is funded by Project PID2021-122355NB-C33 (MCIN/AEI/10.13039/501100011033/ FEDER, UE).

References: [1] Hodgson, D., 2003. The biological foundations of Upper Palaeolithic art: stimulus, percept and representational imperatives. *Rock Art Research*. 20, 3-22. [2] Carrasco, M., 2011. Visual attention: The past 25 years. *Vision Research*. 51, 1484-1525. [3] Friston, K.J., Daunizeau, J., Kiebel, S.J., 2009. Reinforcement learning or active inference? *PLoS ONE*. 4, e6421. [4] Silva-Gago, M., Ioannidou, F., Fedato, A., Hodgson, T., Bruner, E., 2021. Visual Attention and Cognitive Archaeology: An Eye-Tracking Study of Palaeolithic Stone Tools. *Perception*. 51, 3-24. [5] Meyering, L.-E., Kentridge, R., Pettitt, P., 2020. The visual psychology of European Upper Palaeolithic figurative art: using Bubbles to understand outline depictions. *World Archaeology*. 52, 205-222.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## Linked by design: 3D shape covariation in the human postcanine dentition

Petra G. Šimková<sup>1,2</sup>, Viktoria A. Krenn<sup>1,3,4</sup>, Cinzia Fornai<sup>1,2,3,5,6</sup>, Lisa Wurm<sup>7</sup>, Vanda Halász<sup>8</sup>, Dominika Lidinsky<sup>9</sup>, Gerhard W. Weber<sup>1,2,10</sup>

1 - Department of Evolutionary Anthropology, University of Vienna, Austria · 2 - Human Evolution and Archaeological Sciences HEAS, University of Vienna, Austria · 3 - Institute of Evolutionary Medicine, University of Zurich, Switzerland · 4 - Fraunhofer Austria Research GmbH, Klagenfurt, Austria · 5 - Department of Research in Occlusion Medicine, Vienna School of Interdisciplinary Dentistry – VieSID, Klosterneuburg, Austria · 6 - Center for Clinical Research, University Clinic of Dentistry Vienna, Medical University of Vienna, Austria · 7 - Medical Technology Cluster, Business Upper Austria – OÖ Wirtschaftsagentur GmbH, Linz, Austria · 8 - LearnChamp Consulting GmbH & Co KG, Vienna, Austria · 9 - Sandoz GmbH, Kundl, Austria · 10 - Core Facility for Micro-Computed Tomography, University of Vienna, Austria

Understanding morphological integration across human dentition is essential for insights into dental development, function, and evolution. Dental crown shape covariation patterns within and between dental arches, and between different tooth types, is an open field of study. Our study addresses this gap in the current literature by focusing on human postcanine dentition (excluding third molars) using geometric morphometrics [1].

We analyzed a sample of 526 teeth from 136 individuals from 7 geographical populations, based on high-resolution micro-CT scans to generate 3D surface models of dentinal crowns. Both the enamel-dentine junction (EDJ) and cervical outline were considered in our shape analyses. Pairwise shape covariation was assessed among teeth of the same arch and across antagonistic arches, by means of 2-Block Partial Least Squares analysis.

Our results of the 3D dentinal crown analysis showed stronger morphological integration within dental arches rather than between them. High pairwise correlation was observed among adjacent tooth types within dental arches—for instance, between lower premolars (P3-P4,  $r=0.89$ ), upper premolars (P3-P4,  $r=0.81$ ), and upper molars (M1-M2,  $r=0.86$ ). Covariation between antagonistic pairs showed a broader range of correlation values, from a high value between upper and lower M1s ( $r=0.90$ ) to a much lower value between upper P4s and lower M1s ( $r=0.58$ ). Upper M1s consistently showed moderate to high correlation with other tooth types, highlighting their central functional and developmental role in the postcanine dentition [2].

Interestingly, we also detected strong shape covariation between some non-occluding teeth, such as the lower P3s and upper M2s ( $r=0.88$ ). We observed relatively high correlation values between P4s and M1s in the lower ( $r=0.79$ ), as well as the upper ( $r=0.77$ ) jaws. Although P4s and M1s belong to different tooth classes they share a similar masticatory function, both participating in food grinding activities. These results suggest that functional demands and shared developmental pathways may drive morphological covariation even among distinct tooth types.

When analyzing solely the occlusal aspect, excluding the landmarks representing the cervical margin, we observed a notable decrease across pairwise correlation values. This indicates that the height and relative proportions of the crown are dominant factors driving shape covariation between teeth. Nevertheless, we identified reoccurring morphological covariation patterns on the EDJ, such as relative expansion and reduction in the mesiodistal and buccolingual dimensions, across the samples.

This study provides the first comprehensive overview of 3D shape covariation patterns and pairwise correlations among human postcanine tooth types. Our findings contribute to a better understanding of dental shape and offer a foundation for further investigations into developmental biology, and potential phenotype–genotype associations in human dentition.

References: [1] Šimková, P.G., Krenn, V.A., Fornai, C., Wurm, L., Halász, V., Lidinsky, D., Weber, G.W., 2024. Connecting crowns: Analyzing morphological covariation in the modern human postcanine dentition. *bioRxiv*. 2024, 09. [2] Morita, W., Morimoto, N., Ohshima, H., 2016. Exploring metamerism variation in human molars: A morphological study using morphometric mapping. *Journal of Anatomy*. 229, Article 3.

Poster Presentation Number 136, Session 2, Friday 14:00 - 15:30

## Phylogenetic relationships of *Australopithecus*, *Paranthropus*, and *Homo* using integrated traditional morphological data and 3D geometric morphometric data

Margaux Simon-Maciejewski<sup>1,3</sup>, Giorgio Manzi<sup>1</sup>, Valéry Zeitoun<sup>2</sup>, Aurélien Mounier<sup>3,4,5</sup>

1 - Dipartimento di Biologia Ambientale. Sapienza Università di Roma, Rome, Italy · 2 - UMR 7207-CR2P-CNRS-MNHN-Sorbonne Université, Campus Jussieu, Paris, France · 3 - Histoire Naturelle de l'Homme Préhistorique (HNHP, UMR 7194) CNRS/MNHN/UPVD, Musée de l'Homme, Paris, France · 4 - Turkana Basin Institute, Nairobi, Kenya · 5 - CNRS, UAR 3129 – UMIFRE 11 3 Maison Française d'Oxford, Oxford, United Kingdom

Phylogenetic systematics, or cladistics, aims at reconstructing evolutionary relationships by identifying shared derived traits (synapomorphies) inherited from a recent common ancestor, distinguishing them from primitive retentions (symplesiomorphies) and traits that evolved independently (homoplasies). The growing recognition of taxonomic and phyletic diversity in hominin evolution during the 1970s and 1980s coincided with the increasing influence of cladistics in palaeoanthropology [1,2]. For the past two decades, several protocols have been developed to incorporate new data types into cladistic analyses. Among them, methods integrating 3D geometric morphometric (3DGM) data have shown great potential in reassessing phylogenetic relationships and testing evolutionary hypotheses [3,4]. Such a combined approach offers a more comprehensive understanding of hominin phylogeny. While 3D geometric morphometrics effectively capture subtle shape variations, traditional morphological traits encompass a range of anatomical features. Integrating these data types enhances phylogenetic resolution and allows for more robust reconstructions of evolutionary relationships. Overall, the present study highlights the utility of combining landmark-based morphometrics with conventional character matrices to refine phylogenetic hypotheses in human evolution. This integrative methodology contributes to a deeper understanding of hominid diversification and provides a solid framework for future evolutionary analyses.

Following this evolution of analytical protocols and to strengthen its descriptive potential of the phylogenetic relationships among *Australopithecus*, *Paranthropus*, and *Homo* we undertook analyses combining Procrustes-aligned 3D landmark coordinates and discrete morphological characters. A dataset comprising 72 specimens, including 32 fossil hominins and 40 modern human crania produces phylogenetic trees using a three-step protocol: (1) an initial heuristic search in TNT software under equal weighting; (2) calculation of consistency index (CI) and rescaled consistency index (RC) for each character; and (3) a second heuristic search with characters weighted by CI or RC values. The comparative results allow testing different phylogenetic hypotheses previously proposed by authors and offers a more comprehensive understanding of hominin phylogeny. Integrating these data types enhances phylogenetic resolution and allows for more robust reconstructions of evolutionary relationships.

References: [1] Chamberlain, A., Wood, B., 1987. Early hominid phylogeny. *Journal of Human Evolution*. 16, 119–133. [2] Delson, E., Eldredge, N., Tattersall, I., 1977. Reconstruction of hominid phylogeny: A testable framework based on cladistic analysis. *Journal of Human Evolution*. 6, 263–278. [3] Catalano, S.A., Goloboff, P.A., Giannini, N.P., 2010. Phylogenetic morphometrics (I): the use of landmark data in a phylogenetic framework. *Cladistics*. 26, 539–549. [4] Parins-Fukuchi, C., 2018. Use of continuous traits can improve morphological phylogenetics. *Systematic Biology*. 67, 328–339.

Poster Presentation Number 137, Session 2, Friday 14:00 - 15:30

## Fire in Olduvai Gorge: environmental and evolutionary perspectives

Jonathan D. Smolen<sup>1</sup>, Kevin T. Uno<sup>1</sup>, Zander Chearavanont<sup>1</sup>, Troy Ferland<sup>2</sup>, Alfonso Benito Calvo<sup>3</sup>, Jackson Njau<sup>4</sup>, Ignacio de la Torre<sup>5</sup>

1 - Department of Human Evolutionary Biology, Harvard University, Cambridge, MA, USA · 2 - Oak Ridge Institute for Science and Education, Oak Ridge, TN, USA · 3 - Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Paseo Sierra de Atapuerca 3, 09002, Burgos, Spain · 4 - Department of Earth and Atmospheric Sciences, Indiana University, IN, USA · 5 - Instituto de Historia, Spanish National Research Council-CSIC, Madrid, Spain

Hominins evolved in highly variable ecosystems dictated largely by the prevailing climate. The role of wildfire, a force highly sensitive to climate and ecological fluctuations, is recognized as a key component shaping these landscapes and the resources available to hominins and other fauna. As such, understanding the feedback mechanisms between rainfall, vegetation composition, and fire activity is essential for interpreting hominin-environment interactions and their significance within human evolution. Here we consider how these factors, particularly fire, may have influenced the trajectory of human evolution and behavior within Olduvai paleolake basin (~1.9-1.6 million years ago) by leveraging new organic geochemical records from Bed I and Bed II sediments at geological and archaeological sites.

The preservation of organic biomarkers including leaf wax *n*-alkanes and fire-derived polycyclic aromatic hydrocarbons (PAHs) within the continuous, well-dated strata of Richard Hay's geological locality 80 allows us to assess the environmental signal at a regional/landscape level. Molecular distributions and stable isotopic compositions of leaf waxes indicate a relatively stable, open, predominantly C4 ecosystem across much of this period, despite fluctuations in rainfall and temperature driven by climate on orbital timescales. Increased PAH abundance during periods of increased rainfall suggests a fuel load-limited fire regime, where wildfire activity is primarily limited by the amount of vegetation growth possible within low rainfall/semi-arid ecosystems. These records highlight that wildfire within the area was prevalent and modulated by regional climate during this interval, potentially maintaining a relatively open landscape at Olduvai Gorge during climatic conditions that would otherwise promote C3 woody vegetation. Implications such as resource availability, foraging behavior, locomotion, and the development of ecological and faunal niches are considered.

Establishing this regional background signal of ecosystem fire activity is crucial for further interpretation of how fire shaped hominin adaptation. We compare the distributions of these organic geochemical markers at other nearby geological sites against the high-resolution regional signal to better understand the spatial variability within Olduvai Gorge as a whole. From here, we explore data from archaeological excavation sites as an opportunity to search for molecular indications of human-fire interaction. Overall, this framework represents a promising approach to study fire as a pervasive environmental and evolutionary force, underscoring the importance of integrating global and regional paleoenvironmental records into models of hominin land use patterns.

We would like to thank Zander Chearavanont and Annika Dellinger for their assistance in processing samples in the laboratory, as well as the research support from European Research Council (BICAHEFID 832980).

Poster Presentation Number 138, Session 2, Friday 14:00 - 15:30

## The development of tool use in children across cultures

Ellen Soeters<sup>1</sup>, Jake A. Funkhouser<sup>1,2</sup>, Erik P. Willems<sup>1</sup>, Ardain Dzabatou<sup>3</sup>, Sarah Pope-Caldwell<sup>3,4</sup>, Crickette Sanz<sup>2,5</sup>, Kathelijne Koops<sup>1</sup>

1 - Department of Evolutionary Anthropology, University of Zurich, Switzerland · 2 - Department of Anthropology, Washington University in St. Louis, USA · 3 - Department for Comparative Cultural Psychology, Max Planck Institute for Evolutionary Anthropology, Germany · 4 - Department of Psychology, Georgia State University, USA · 5 - Wildlife Conservation Society, Congo Program, Republic of Congo

Tool use is ubiquitous to all human societies today. The earliest evidence of human tool use and manufacture (i.e., material culture) has been traced back to at least 3.3 million years ago. Still, our understanding of how complex tool use skills emerged and how they continue to be maintained is debated. In human societies, tool use is inherently cultural and is shaped by social learning and developmental processes. The preparation for tool use hypothesis suggests that object manipulation precipitates the ontogenetic emergence of tool use, yet it is not known if this trend differs across human cultures. We explored how social opportunities (conspecifics within 1 m), object availability (objects within 1 m), and manipulation complexity (an increase in the number of objects) influenced tool use development across cultures. We conducted systematic observational video focal follows with children (0.5–5 years) in their natural activities from three communities: BaYaka foragers and Bandongo fisher-farmers (Republic of the Congo), and daycare children (Switzerland). Our analyses indicated that the complexity of all children's object manipulation increased with age (estimate=0.40, CI [0.19, 0.61],  $p < 0.001$ ), supporting the preparation for tool use hypothesis. However, children in Swiss daycares engaged in longer and more complex manipulations than both Congolese communities. Social opportunities had no effect on complexity but significantly predicted shorter manipulation durations, suggesting that children may change their focus in social contexts. In contrast, object availability had no effect on duration but positively affected complexity, suggesting that the availability of objects, not conspecifics, may facilitate more complex object manipulation. Overall, our findings indicate that while tool use development shows universal age-related patterns across cultures, developmental trajectories are further shaped by cultural inputs. This highlights the role of cultural variation in shaping tool use behaviours and offers key insights into the evolution of human material culture.

We thank the Swiss National Science Foundation for funding this research, and the Research Ethics Committees at the University of Zurich and the Max Planck Institute for granting ethical approval. We are grateful to the students and employees at the University of Zurich and Washington University in St Louis for piloting our study protocol and for assistance with video analyses. We thank the parents of the participating children for their trust and consent. A special thanks goes to the carers and staff at the daycares who work tirelessly, and to the research teams in Congo, for their time, collaboration and invaluable guidance throughout this study.

Poster Presentation Number 139, Session 2, Friday 14:00 - 15:30

## Quantifying technical processes on a continuous scale

Marie Soressi<sup>1</sup>, Leonardo Carmignani<sup>1</sup>, Jesse Kuijt<sup>1</sup>, Sebastian Fajardo<sup>2</sup>, Erik Kroon<sup>1</sup>

1 - Faculty of Archaeology, Leiden University, The Netherlands · 2 - Leiden Institute of Advanced Computer Science, Leiden University, The Netherlands

Stone tools have long served as key evidence in reconstructing hominin cultural diversity. In France, the social and cultural dimensions of technology, particularly the technical gestures involved in tool production and use, have been central to archaeological inquiry since the mid-20th century, notably through the work of Leroi-Gourhan and others influenced by Marcel Mauss. This perspective laid the groundwork for an Anthropology of Technology and the later development of the *chaîne opératoire* approach to lithic analysis [1].

The rise of ancient DNA research and the introduction of cumulative cultural evolution theory [2] have renewed interest in aligning biological and cultural frameworks. This year's celebration of Cavalli-Sforza's pioneering work highlights the enduring importance of integrating genetic and cultural perspectives in the study of human evolution [e.g. 3]. Yet, this integration remains a key challenge, particularly in lithic studies, where analyses still rely heavily on descriptive narratives, schematic illustrations, and basic typological or metric data of individual features.

This paper reviews several innovative methodological tools that hold promise for the formal and quantitative analysis of technical processes, both in their entirety and in their variability. We examine the potential of network analysis to measure similarities in decision pathways [4], the adaptation of Petri nets modeling from computer science to evaluate behavioral complexity [5], and the use of Multiple Correspondence Analysis (MCA) to compare patterns among lithic assemblages. We also assess the limitations of *chaîne opératoire* analysis and the extent to which statistically analyzable data can capture the necessary variability, granularity, and qualitative nuance to study cultural dynamics during the late Pleistocene.

Our findings suggest that recent methodological advances now allow for increasingly robust mathematical formalization and modelling of technical processes in their entirety. While no single method fits all research questions and further development is still needed, these tools already open new avenues for hypothesis-driven studies. Importantly, they also highlight the need to refine *chaîne opératoire* analysis as a descriptive foundation for quantitative approaches.

References: [1] Soressi, M., Geneste, J.M., 2011. The history and efficacy of the chaîne opératoire approach to lithic analysis: studying techniques to reveal past societies in an evolutionary perspective. *PaleoAnthropology*. 2011, 334–350. [2] Richerson, P.J., Boyd, R., Henrich, J., 2010. Gene-culture coevolution in the age of genomics. *Proceedings of the National Academy of Sciences*. 107, 8985–8992. [3] Colucci, M., Leonardi, M., Hodgson, J.A., Stringer, C., Scerri, E.M.L., 2025. The legacy of Luca Cavalli-Sforza on human evolution. *Human Population Genetics and Genomics*. [4] Kroon, E., 2024. Serial Learners. Interactions between Funnel Beaker West and Corded Ware Communities in the Netherlands during the Third Millennium BCE from the Perspective of Ceramic Technology. PhD dissertation, Leiden University. Sidestone Press Dissertations. 270 p. [5] Fajardo, S., Kozowyk, P.R.B., Langejans, G.H.J., 2023. Measuring ancient technological complexity and its cognitive implications using Petri nets. *Scientific Reports*. 13.

Podium Presentation, Session 7, Saturday 08:30 – 10:30

## From function to phylogeny: exploring the unique structure of the Neanderthal calcaneus

Rita Sorrentino<sup>1</sup>, Silvia Volpe<sup>1</sup>, Kristian J. Carlson<sup>2,3</sup>, Teresa Nicolosi<sup>1,4</sup>, Carla Figus<sup>4</sup>, Vitale Sparacello<sup>5</sup>, Jaap P. P. Saers<sup>6</sup>, Francesca Meli<sup>7</sup>, Michele Conconi<sup>8</sup>, Nicola Sancisi<sup>8</sup>, Claudio Belvedere<sup>9</sup>, Alberto Leardini<sup>9</sup>, Jean-Jacques Hublin<sup>10,11</sup>, Timothy Ryan<sup>12</sup>, Luca Sineo<sup>7</sup>, Antonio Rosas<sup>13</sup>, Stefano Benazzi<sup>4</sup>, Maria Giovanna Belcastro<sup>1</sup>

1 - Department of Biological, Geological and Environmental Sciences, University of Bologna, Bologna, Italy · 2 - Division of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, Los Angeles, USA · 3 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, WITS, South Africa · 4 - Department of Cultural Heritage, University of Bologna, Ravenna, Italy · 5 - Department of Life and Environmental Sciences, University of Cagliari, Cittadella Monserrato, Cagliari, Italy · 6 - Naturalis Biodiversity Center, Leiden, the Netherlands · 7 - Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STEBICEF), - University of Palermo, Palermo, Italy · 8 - Department of Industrial Engineering, Health Sciences and Technologies, Interdepartmental Centre for Industrial Research (HST-ICIR), University of Bologna, Bologna, Italy · 9 - Laboratory of Movement Analysis and Functional Evaluation of Prostheses, IRCCS Istituto Ortopedico Rizzoli, Bologna, Italy · 10 - Chaire Internationale de Paléanthropologie, CIRB (UMR 7241-U1050), Collège de France, Paris, France · 11 - Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 12 - Department of Anthropology, The Pennsylvania State University, State College, PA, USA · 13 - Group of Paleoanthropology, Department of Palaeobiology, Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain

Neanderthals display distinct morphological adaptations in the calcaneus compared to *H. sapiens*, providing important insights into evolutionary pressures and functional demands unique to their lineage. While both groups have some similar foot proportions, Neanderthal calcanei exhibit specialized traits, including expanded talar articular surfaces, a projecting sustentaculum tali, and a broader tuberosity [1-3]. These features are often attributed to generalized skeletal robusticity, yet their calcaneal distinctiveness suggests additional biomechanical and evolutionary influences. This study evaluates whether these morphological differences arise from functional behaviors or phylogenetic factors. External calcaneal morphology was captured through a 3D template of 276 (semi)landmarks, in a sample of 7 Neanderthals and 64 *H. sapiens*. The *H. sapiens* sample includes individuals with varied mobility strategies, from highly mobile hunter-gatherers, either barefoot or wearing soft foot coverings, to sedentary post-industrial groups wearing hard footwear. Four separate generalized Procrustes analyses were performed on the Cartesian coordinates of the whole calcaneus, the talar facets, the cuboid facet, and the tuberosity using the R package Geomorph v 4.0.1. Semilandmarks were allowed to slide during each recursive update of the Procrustes consensus [4]. Statistical analyses (e.g., Procrustes ANOVA and PCA) assessed the roles of shape (Procrustes coordinates), size (natural logarithm of centroid size), and allometry (shape:size) in group differences. Results show that species/group is the main factor determining calcaneal shape differences, while size accounts only for subtle variation in the tuberosity within *H. sapiens*. Neanderthal calcanei exhibit a distinct configuration, with notable differences in the talar facets and tuberosity, while the cuboid facet falls within *H. sapiens* variability. Specifically, Neanderthals have shorter, taller, and wider calcanei compared to *H. sapiens*. Their calcanei combine traits such as a more medially convex and laterally expanded posterior talar facet, an enlarged anterior talar facet, a more plantarly oriented sustentaculum tali, and a markedly reduced lateral plantar process of the tuberosity. The shape of the tuberosity and talar facets aligns with a habitually pronated foot posture, as suggested for the Neanderthal talus [5], likely compensating for greater body mass and repetitive loading during locomotion. A shortened anteroposterior sinus tarsi - shared with other Pleistocene *Homo* - suggests ancestral retention, while similarities in calcaneal breadth with hunter-gatherer *H. sapiens* highlight convergent adaptations to high mobility. Neanderthal calcaneal morphology reflects a mosaic of phylogenetic traits and biomechanical adaptations to intense locomotor loading. Their calcaneal configuration underscores divergent evolutionary pathways from *H. sapiens*, shaped by ecological demands and inherited skeletal traits.

This work was funded by the Spanish Ministry of Science and Innovation through the projects PID2021-122356NB-I00 to AR. We thank the curators and collections managers of the sample used in this study: F. Déroit, D. Hervé, A. Balzeau, P. Menecier, and A. Froment (Muséum National d'Histoire Naturelle, Département Hommes, Natures, Sociétés) for providing digital models of La Ferrassie 1 and 2, and La Chapelle; R. Macchiarelli, A. Mazurier, and V. Volpato (University of Poitiers) for the microCT scan of Regourdou calcaneus performed at the European Synchrotron Radiation Facility, Grenoble, France; Max Planck Institute for Evolutionary Anthropology for access to Qafzeh 8 and 9, Skhul 4, and Dolní Věstonice 15; Museo di Paleontologia "Gemmellaro", Palermo (Italy), for access to San Teodoro 1; all of the people working at the El Sidrón collection for their effort and interest; "Soprintendenza Archeologia, Belle Arti e Paesaggio per la città metropolitana di Genova e la provincia di La Spezia" and "Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Imperia e Savona" provided access to the Arenè Candide individuals appearing in Sparacello et al., 2018a, the collection of which was funded by Marie-Curie European Union COFUND/Durham Junior Research Fellowship [under EU grant agreement number 267209], and by the Wolfson Institute for Health and Wellbeing, Durham, UK, the files were downloaded from www.MorphoSource.org, Duke University. Access to the Spy 2 sample was made possible by the NESPOS (Neanderthal Studies Professional Online Service) Database (<https://www.nespos.org/display/openspace/Home>).

References: [1] Trinkaus, E., Churchill, S.E., Ruff, C.B., 1991. Robusticity versus shape: The functional interpretation of Neanderthal appendicular morphology. *Journal of the Anthropological Society of Nippon*. 99, 257–278. [2] Pablos, A., Arsuaga, J.L., 2024. Tarsals from the Sima de los Huesos Middle Pleistocene site (Atapuerca, Burgos, Spain). *Anatomical Record*. 307, e25425. [3] Raichlen, D.A., Armstrong, H., Lieberman, D.E., 2011. Calcaneus length determines running economy: Implications for endurance running performance in modern humans and Neanderthals. *Journal of Human Evolution*. 60, 299–308. [4] Slice, D.E., 2006. Modern morphometrics in physical anthropology. Springer Science & Business Media. [5] Sorrentino, R., Stephens, N.B., Marchi, D., DeMars, L.J.D., Figus, C., Bortolini, E., Badino, F., Saers, J.P.P., Bettuzzi, M., Boschini, F., Capocchi, G., Feletti, F., Guarnieri, T., May, H., Morigi, M.P., Parr, W., Ricci, S., Ronchitelli, A., Stock, J.T., Carlson, K.J., Ryan, T.M., Belcastro, M.G., Benazzi, S., 2021. Unique foot posture in Neanderthals reflects their body mass and high mechanical stress. *Journal of Human Evolution*. 161, 103093.

Poster Presentation Number 140, Session 2, Friday 14:00 - 15:30

## **Ras el-Kelb (Lebanon) and the Middle Palaeolithic: insights into hominin ecology and site function**

**Marya Soubra<sup>1</sup>, Yamandú H. Hilbert<sup>1</sup>, Gabriele Russo<sup>1</sup>, Maya Haïdar-Boustani<sup>2</sup>, Andrew Garrard<sup>3</sup>, Sireen El Zaatari<sup>1</sup>**

1 - Paleoanthropology, Senckenberg Centre for Human Evolution and Palaeoenvironment, Institute of Archaeological Sciences, University of Tübingen, Germany · 2 - Museum of Lebanese Prehistory-Saint Joseph University, Lebanon · 3 - University College London, UK

The Middle Palaeolithic of the Levant remains a topic of discussion in terms of cultural variability, technological traditions, and hominin occupation. The site of Ras el-Kelb, located on the foot of Mount Lebanon, on the coastal cliffs of the Nahr el-Kelb valley, yielded evidence of Middle Palaeolithic hominin occupation. Known since the end of the 1800s [1] and partially excavated in the 1950s by Dorothy Garrod and Germaine Henri-Martin during rescue operations, the significance of its rich assemblages of lithics, fauna, and human remains is well-recognized, even if they remain poorly studied [2]. Here, we revisit a collection of the lithics from these excavations with the objective to investigate technological and cultural variability in relation to environmental and geographic contexts. We focus on exploring hominin landscape use, raw material exploitation, and subsistence strategies.

For this study, lithic artefacts were qualitatively and quantitatively assessed. Typological and technological classifications were conducted, alongside metric analysis. Use-wear analysis, with both low- and high-power microscopic techniques, were also employed to characterize tool function. Our results reveal that the lithics were a typical Levallois Mousterian assemblage in terms of typology and metrics. The flint quality suggests a preference for large pieces of good-quality source material, which is not available in the immediate vicinity of the site. The use-wear analysis indicates that the lithics were mainly used for cutting and scraping plant and animal materials. We thus argue for a domestic camp function for the site. This is supported by the results of the assessments and reassessments of the faunal assemblages, which identify hunting and processing activities of various animal species at the site with a seasonal pattern of selection [3,4]. The combination of the lithics and faunal analyses highlights the role of the site as a seasonal domestic camp, providing insight into hominin landscape use and resource exploitation during the Middle Palaeolithic. It sheds light on hominin behavioural flexibility and adaptations during this time period of cultural and evolutionary transitions. We will discuss the new results from Ras el-Kelb into the regional Lebanese and also wider Levantine contexts focusing on the Middle Palaeolithic lithic variability and its relationship to ecogeographic factors, hence contributing to the discussions on hominin adaptive strategies during the Levantine Middle Palaeolithic.

This research is funded by the European Research Council under the European Union's Horizon 2020 research and innovation program, grant agreement number 101001889 (REVIVE). The REVIVE project is being conducted in close collaboration with the Lebanese Directorate General of Antiquities, Ministry of Culture.

References: [1] Zumoffen, G., 1900. *La Phénicie avant les Phéniciens: L'Âge de Pierre*. Imprimerie Catholique, Beirut. [2] Copeland, L., Moloney, N., 1998. The Mousterian Site of Ras el-Kelb, Lebanon. BAR International Series 706. Archaeopress, Oxford. [3] Garrard, A., 1998. Food procurement by Middle Palaeolithic hominids at Ras el-Kelb Cave in Lebanon. In: Copeland, L., Moloney, N. (Eds.), *The Mousterian Site of Ras el-Kelb, Lebanon*. BAR International Series 706. Archaeopress, Oxford, pp. 45-65. [4] Russo, G., Rivals, R., Duval, M., McLin, S., Abo Fakher, M. A., Haïdar-Boustani, M., Garrard, A., and El Zaatari, S., in prep. Middle Palaeolithic hominin ecology and subsistence in the Central Levant.

Poster Presentation Number 141, Session 2, Friday 14:00 - 15:30

## The Krems-Wachtberg infant 4

**Stefanie Stelzer<sup>1</sup>, Veronika Kaudela<sup>1,2</sup>, Thomas Einwögerer<sup>2</sup>, Marc Händel<sup>2</sup>, Andreas Reisinger<sup>1</sup>, Hannah Rohringer<sup>2</sup>, Maria Teschler-Nicola<sup>3,4</sup>**

1 - Department of Anatomy and Biomechanics, Karl Landsteiner University of Health Sciences, Krems an der Donau, Austria · 2 - Austrian Archaeological Institute, Austrian Academy of Sciences, Austria · 3 - Department of Anthropology, Natural History Museum Vienna, Austria · 4 - Department of Evolutionary Anthropology, University of Vienna, Austria

Since the discovery of the 31,000-year-old Upper Palaeolithic neonates (Individual 1 and 2) and the approximately 3-month-old infant (Individual 3) beginning in 2005, the site of Krems-Wachtberg, Austria, has provided significant insights into the lives of early modern humans in the region. The careful interment of these infants has shaped our understanding of Upper Palaeolithic cultural practices. Ancient DNA analyses identified the newborns as monozygotic male twins, and the infant from the single grave as their third-degree male relative. Histological and  $\mu$ CT examinations of the twins' teeth, combined with C- and N-isotope ratios and Barium (Ba) levels as a breastfeed marker, suggest that Individual 2 died at birth, while Individual 1 survived for approximately 50 days [1].

We now introduce a fourth individual, represented by a well-preserved rib, which we refer to as Individual 4. Discovered in 2007, this specimen (Wa-44448) belonged to an adolescent. Unlike the other three individuals found in their burial contexts, the rib was recovered in a part of the main archaeological horizon (AH 4.11) that shows signs of finds being moved by post-occupational slope processes (AH 4.11) [2]. It was probably exposed on the surface for a long time, but it may originally have come from a burial located further up the slope [3]. In this study we present the morphological data and  $\mu$ CT images produced in the frame of an ongoing project to digitize the complete skeletons of the twins recovered from Burial 1.

The fossil record of early modern humans in Europe is limited, particularly for subadults. The four individuals recovered at Krems-Wachtberg therefore provide valuable insights into the lives of Upper Palaeolithic humans. The burials emphasize the site's significance in terms of behavioural and cultural development as well as its connections to other Gravettian sites across Europe. Furthermore, these human remains will enhance our understanding of the anatomy and ontogenetic development of early modern humans in Central Europe.

This research is funded by the GFF as part of the RTI Strategy Lower Austria 2027.

References: [1] Teschler-Nicola, M., Fernandes, D., Händel, M., Einwögerer, T., Simon, U., Neugebauer-Maresch, C., Tangl, S., Heimel, P., Dobsak, T., Retzmann, A., Prohaska, T., Irrgeher, J., Kennett, D.J., Olalde, I., Reich, D., Pinhasi, R., 2020. Ancient DNA reveals monozygotic newborn twins from the Upper Palaeolithic. *Communications Biology*. 3. [2] Händel, M., Einwögerer, T., Simon, U., 2008. Krems-Wachtberg—a Gravettian settlement site in the Middle Danube region. *Wissenschaftliche Mitteilungen aus dem Niederösterreichischen Landesmuseum*. 19, 108. [3] Einwögerer, T., Simon, U., Händel, M., 2008. Neue Gravettienfunde vom Wachtberg in Krems an der Donau. *Das Waldviertel*. 57, 171–175.

Poster Presentation Number 142, Session 2, Friday 14:00 - 15:30

## When less is more: risk and reward in handaxe manufacture and the impact of skill

Finn Stileman<sup>1</sup>

1 - University of Cambridge

Linking stone tool artefacts to cognition and expertise represents a major pursuit of palaeoanthropology as these are the most accessible manifestations of technology across the Palaeolithic record. Handaxes are of special interest as the earliest tools with clear design modalities and spanning major evolutionary events in the *Homo* genus between 1.8 and 0.2 million years ago [1]. Prior knapping experiments have evidenced the prolonged practice necessary in replicating later Acheulean biface forms, achieved through extended flaking sequences [2]. Bifaces produced by novices are characteristically thick, irregular and asymmetric, more similar to early Acheulean assemblages [3]. A new experiment tracking handaxe reduction by expert and novice knappers details discrepancies, not only in their final configurations, but in their patterns of change from starting blanks, to rough-outs, and finished forms. Flaking sequences, 3D morphologies and edge integrity (e.g. crushing) were all tracked, providing the most detailed analysis of bifacial reduction so far reported, and contextualised by skill level for the first time. Whereas late-stage reduction consistently improves handaxe attributes for experts, continued reduction is associated with the accumulation of knapping errors and edge degradation for novices, providing incentive to adopt conservative flaking strategies protecting functionality. This scenario presents a conflict between the immediate goals of tool use and long-term trajectories in skill acquisition; risk-aversion can yield short-term benefits but will hinder expansion of the technological repertoire. The prioritisation of short-term goals may partly explain the expression of simple and relatively unstandardised handaxe technology during the Early Pleistocene. We suggest that the expertise required to produce bifaces typical of Middle Pleistocene assemblages required a greater propensity to incur short-term costs, indicating deliberate practice of difficult skills that are initially counter-productive. Conscientious investment in future skills signifies ‘mental time travel’ and holds important implications for cognitive evolution and cumulative culture.

We are grateful to the 20 participants who took part in this project, the Cambridge Archaeology Unit who provided facilities for the experiment, and to the Natural Environment Research Council for funding the research through the C-CLEAR Doctoral Training Partnership.

References: [1] Kuhn, S.L., 2020. *The Evolution of Paleolithic Technologies*. Routledge. [2] Pargeter, J., Khreisheh, N., Stout, D., 2019. Understanding stone tool-making skill acquisition: Experimental methods and evolutionary implications. *Journal of Human Evolution*. 133, 146–166. [3] Liu, C., Khreisheh, N., Stout, D., Pargeter, J., 2023. Differential effects of knapping skill acquisition on the cultural reproduction of Late Acheulean handaxe morphology: Archaeological and experimental insights. *Journal of Archaeological Science: Reports*. 49, 103974.

Poster Presentation Number 143, Session 2, Friday 14:00 - 15:30

## Ancient genome from Central Balkans reveals genetic substructure within populations associated with the Gravettian culture

Arev Pelin Sümer<sup>1</sup>, Predrag Radović<sup>2</sup>, Vanessa Villalba-Mouco<sup>1,3</sup>, Helen Fewlass<sup>4</sup>, Elena Essel<sup>1</sup>, Joshua Lindal<sup>5,6</sup>, Vesna Dimitrijević<sup>2</sup>, Cosimo Posth<sup>7</sup>, Mateja Hajdinjak<sup>1</sup>, Mirjana Rokсандić<sup>5,6</sup>, Dušan Mihailović<sup>2</sup>, Johannes Krause<sup>1</sup>

1 - Max Planck Institute for Evolutionary Anthropology, Germany · 2 - Department of Archaeology, Faculty of Philosophy, University of Belgrade, Serbia · 3 - Institute of Evolutionary Biology, CSIC-Universitat Pompeu Fabra, Barcelona, Spain · 4 - Department of Anthropology and Archaeology, University of Bristol, Bristol, UK · 5 - Department of Anthropology, University of Winnipeg, Winnipeg, Manitoba, Canada · 6 - Department of Anthropology, University of Manitoba, Winnipeg, Manitoba, Canada · 7 - Institute for Archaeological Sciences, Tübingen University, Tübingen, Germany

A human mandibular fragment, Kozja 1, was excavated in 2020 from the Upper Pleistocene deposits of Kozja Cave, located near Majdanpek in eastern Serbia. The specimen exhibits overall modern human morphology, yet interestingly displays certain features more commonly associated with Neandertals (e.g. horizontal-oval mandibular foramen). It represents a robust adult individual. Kozja 1 was recovered from layer 2a2, in association with Middle Paleolithic artifacts, within a context disturbed by cave bear activity. Radiocarbon dating revealed an age of 32,080–31,550 cal BP at 95% probability, suggesting an association with the Gravettian culture, remains of which were found in layer 1c3, as well as in the adjacent Mala Cave.

Before the Last Glacial Maximum (LGM), two genetically distinct groups associated with Gravettian occupied Europe between 33,000 and 26,000 years before present [1]. One of these groups include eastern and southern European sites in modern-day Czechia, Austria and Italy and was named “Vestonice cluster” after the Dolní Věstonice site [1,2]. The second is the “Fournol cluster”, and consists of western European sites in present-day France and Spain [1]. Eastern Gravettian ancestry represented by the Vestonice cluster was previously not found in the post-LGM populations [1]. By analyzing ancient DNA from the Kozja 1 specimen, we assigned it to a male individual who carried mitochondrial DNA haplogroup U5, which is highly common in Late Paleolithic and Mesolithic hunter-gatherers and already observed in Gravettian-associated individuals [1]. The Y-chromosome haplogroup of Kozja 1 is C1a2, also found in other individuals associated with the Vestonice cluster. At the autosomal level, Kozja 1 grouped with other eastern Gravettian individuals, while having the highest genetic similarity with Vestonice 43. Together, these two individuals represent a genetic subcluster distinct from the main group in Dolní Věstonice, which includes Vestonice 162, Vestonice 132, DV14 (DLV005) [1,2], DV15 (DLV006) [1,2], as well as another Gravettian individual from Austria (Austria\_Krems1\_14). The Kozja 1-Vestonice 43 subcluster is also genetically more distant to individuals associated with the Gravettian culture found in southern Italy, such as Paglicci 121 and Ostuni 2. Using various *f<sub>4</sub>*-statistics, we show that several post-LGM Epigravettian-associated individuals from the Italian Peninsula show significantly higher affinity to the Kozja 1-Vestonice 43, than to other Gravettian individuals across Europe.

Our findings indicate that there may have been genetic exchange between the Kozja 1-Vestonice 43 subcluster and the Epigravettian-associated population (Villabruna cluster) that settled the Italian Peninsula following the LGM beginning around 20,000 years ago [2]. This post-LGM population likely migrated from the Balkans westward to the Italian Peninsula. During this movement, they might have encountered the descendants of the Kozja 1-Vestonice 43 group on the Balkan Peninsula, and continued their westward spread after the genetic exchange between the two groups.

The presented results make Kozja 1 the oldest modern human genome from the central Balkans, providing insight into the population structure of eastern Gravettians, as well as their relationships to the human groups that populated large parts of Europe after the LGM.

This research has been supported by the Ministry of Culture of the Republic of Serbia, the NEEMO project funded by the Science Fund of the Republic of Serbia (7746827), and the MIRA project funded by the Social Sciences and Humanities Research Council of Canada (895-2024-1005).

References: [1] Posth, C., Yu, H., Ghalichi, A., Rougier, H., Crevecoeur, I., Huang, Y., Ringbauer, H., Rohrlach, A.B., Nägele, K., Villalba-Mouco, V., Radzeviciute, R., Ferraz, T., Stöckel, A., Tukhbatova, R., Drucker, D.G., Lari, M., Modi, A., Vai, S., Sauepe, T., Scheib, C.L., Catalano, G., Pagani, L., Talamo, S., Fewlass, H., Klaric, L., Morala, A., Rué, M., Madeline, S., Crépin, L., Caverne, J.-B., Bocaege, E., Ricci, S., Boschini, F., Bayle, P., Maureille, B., Le Brun-Ricalens, F., Bordes, J.-G., Oxilia, G., Bortolini, E., Bignon-Lau, O., Debout, G., Orliac, M., Zazzo, A., Sparacello, V., Starnini, E., Sincio, L., van der Plicht, J., Pecqueur, L., Merceron, G., Garcia, G., Leuvey, J.-M., Garcia, C.B., Gómez-Olivencia, A., Poltowicz-Bobak, M., Bobak, D., Le Luyer, M., Storm, P., Hoffmann, C., Kabaciński, J., Filimonova, T., Shneider, S., Berezina, N., González-Rabanal, B., González-Morales, M.R., Marin-Arroyo, A.B., López, B., Alonso-Llamazares, C., Ronchitelli, A., Polet, C., Jadin, I., Cauwe, N., Soler, J., Coromina, N., Ruff, I., Cottiaux, R., Clark, G., Straus, L.G., Julien, M.-A., Renhart, S., Talaa, D., Benazzi, S., Romandini, M., Amkreutz, L., Bocherens, H., Wißing, C., Villotte, S., de Pablo, J.F.-L., Gómez-Puche, M., Esquembre-Bebia, M.A., Bodu, P., Smits, L., Souffi, B., Jankauskas, R., Kozakaitė, J., Cupillard, C., Benthien, H., Wehrberger, K., Schmitz, R.W., Feine, S.C., Schüller, T., Thevenet, C., Grigorescu, D., Luth, F., Kotula, A., Piezonka, H., Schopper, F., Svoboda, J., Szeleová, S., Chizhevsky, A., Khokhlov, A., Conard, N.J., Valentin, F., Harvati, K., Semal, P., Jungklaus, B., Suvorov, A., Schulting, R., Moiseyev, V., Mannermaa, K., Buzhilova, A., Terberger, T., Caramelli, D., Altena, E., Haak, W., Krause, J., 2023. Palaeogenomics of Upper Palaeolithic to Neolithic European hunter-gatherers. *Nature*. 615, 117–126. [2] Fu, Q., Posth, C., Hajdinjak, M., Petr, M., Mallick, S., Fernandes, D., Furtwängler, A., Haak, W., Meyer, M., Mittnik, A., Nickel, B., Peltzer, A., Rohland, N., Slon, V., Talamo, S., Lazaridis, I., Lipson, M., Mathieson, I., Schiffels, S., Skoglund, P., Derevianko, A.P., Droszdz, N., Slavinsky, V., Tsybankov, A., Cremonesi, R.G., Mallegni, F., Gély, B., Vacca, E., Morales, M.R.G., Straus, L.G., Neugebauer-Maresch, C., Teschler-Nicola, M., Constantin, S., Moldovan, O.T., Benazzi, S., Peresani, M., Coppola, D., Lari, M., Ricci, S., Ronchitelli, A., Valentin, F., Thevenet, C., Wehrberger, K., Grigorescu, D., Rougier, H., Crevecoeur, I., Flas, D., Semal, P., Mannino, M.A., Cupillard, C., Bocherens, H., Conard, N.J., Harvati, K., Moiseyev, V., Drucker, D.G., Svoboda, J., Richards, M.P., Caramelli, D., Pinhasi, R., Kelso, J., Patterson, N., Krause, J., Pääbo, S., Reich, D., 2016. The genetic history of Ice Age Europe. *Nature*. 534, 200–205. [3] Posth, C., Renaud, G., Mittnik, A., Drucker, D.G., Rougier, H., Cupillard, C., Valentin, F., Thevenet, C., Furtwängler, A., Wißing, C., Francken, M., Malina, M., Bolus, M., Lari, M., Gigli, E., Capocchi, G., Crevecoeur, I., Beauval, C., Flas, D., Germonpré, M., van der Plicht, J., Cottiaux, R., Gély, B., Ronchitelli, A., Wehrberger, K., Grigorescu, D., Svoboda, J., Semal, P., Caramelli, D., Bocherens, H., Harvati, K., Conard, N.J., Haak, W., Powell, A., Krause, J., 2016. Pleistocene Mitochondrial Genomes Suggest a Single Major Dispersal of Non-Africans and a Late Glacial Population Turnover in Europe. *Current Biology*. 26, 827–833.

- [4] Teschler-Nicola, M., Fernandes, D., Händel, M., Einwögerer, T., Simon, U., Neugebauer-Maresch, C., Tangl, S., Heimel, P., Dobsak, T., Retzmann, A., Prohaska, T., Irrgeher, J., Kennett, D.J., Olalde, I., Reich, D., Pinhasi, R., 2020. Ancient DNA reveals monozygotic newborn twins from the Upper Palaeolithic. *Communications Biology*. 3.

Poster Presentation Number 144, Session 2, Friday 14:00 - 15:30

## Exploring applications of intraoral 3D scanning technology in paleontology

Jerome Surault<sup>1</sup>, Lizon Delomosne<sup>1</sup>, Camille Grohé<sup>1</sup>, Franck Guy<sup>1</sup>, Harmony Hill<sup>1</sup>, Amélie Beaudet<sup>1</sup>

1 - Laboratoire de Paléontologie, Évolution, Paléoécosystèmes et Paléoprimatologie (PALEVOPRIM), UMR 7262 CNRS & Université de Poitiers, France

3D imaging techniques have become an essential part of the investigative toolkit of paleontologists in the study of fossil remains. The 3D models are not only used for research purposes through comparative anatomy or morphometric studies, but also represent relevant resources for teaching or outreach activities, as well as for sharing 3D data and the curation of valuable, unique and often fragile fossil specimens.

Through various methods and equipment, highly accurate digital copies can now be generated. 3D models are partly originated from 3D scanning, known as "surface scanning" [1,2]. Techniques like photogrammetry, laser scanning, and structured light scanning capture the outer surface of an object, often including texture. Because of the portable nature of the equipment, these methods are widely used for digitizing fossil specimens in museums or research institutions.

However, their usage is predominantly limited to digitizing large objects ranging from centimeters to decimeters in size. Recent advances in scanning techniques, in particular the development of intraoral scanners, offer promising alternatives to overcome these limitations [3-5]. Originally developed in dentistry to digitize dental structures in vivo with high precision, we here demonstrate that intraoral scanners can be successfully used for scanning small fossil skeletal remains, producing 3D models of comparable quality than those generated by traditional 3D scanners. In particular, we compare technical performance of the intraoral scanner (Medit i700) against a benchmark in mobile structured light scanning (Artec Space Spider) and assess their strengths and advantages and limitations on millimeter to centimeter scale fossil specimens.

To account for the effect of size and morphology of fossils in creating 3D models, we selected 10 specimens of various taxa (hominins, cercopithecids, cetartiodactyles, carnivores, rodents) from diverse localities (e.g., Villebramar in France, Toros Menalla in Chad, Shungura in Ethiopia). The specimens, composed of various dental or osseous elements, were digitized with both scanners and reconstructed in 3D using dedicated software (Artec Studio 17, Medit Scan for Clinics). Distance between the two reconstructions were then automatically measured for each specimen with the software Avizo Lite 2020.2 and Geomagic Wrap. The results obtained suggest that both techniques produce 3D models with only small differences of resolution detected (e.g., less than 0.5 mm for the bovid horn-core).

Experimentally, the intraoral scanner offers a simpler, more automated workflow than the Artec, which requires multiple steps and manual processing. The Medit, with a resolution of up to 11 µm and 70 fps capture, significantly outperforms the Artec (100 µm, 6 fps) in speed and image density. While both produce comparable textures, the Medit performs better on shiny surfaces like enamel. By comparing the morphologies and dimensions of the 3D models, the intraoral scanner accurately captured the surfaces of dental structures ranging from centimeter-sized (anthracothere hemimandible) to 5 mm (teeth of rodent, cainothere or small carnivores). Finally, the Medit has proven its ability to scan elements other than teeth, such as cranial and postcranial bone samples. However, intra-oral scanning is highly automated, particularly during the image alignment phases, which can cause problems of aberrant overlap when the 3D model is reconstructed. Very thin, flat surfaces are particularly prone to this type of error. In addition, automated smoothing, that cannot be disabled, reduces the accuracy of certain small anatomical features.

Intraoral scanners have demonstrated their ability to digitize small fossil specimens, despite their limitations. Thanks to their simplicity and practicality, the integration of this technical tool represents an interesting alternative in paleontology for obtaining textured 3D models with high-quality precision.

This project has received financial support from the CNRS through the MITI interdisciplinary program "Jumeaux Numériques" (to A.B.). The intraoral scanner has been funded by the "AAP Soutien à l'acquisition d'équipements scientifiques" 2024 from the University of Poitiers (to C.G.).

References: [1] Diez Diaz, V., Mallison, H., Asbach, P., Szwarc, D., Blanco, A., 2021. Comparing surface digitization techniques in palaeontology using visual perceptual metrics and distance computations between 3D meshes. *Palaeontology*. 64, 179–202. [2] Garashchenko, Y., Kogan, I., Rucki, M., 2022. Comparative accuracy analysis of triangulated surface models of a fossil skull digitized with various optic devices. *Metrology and Measurement Systems*. 29, 37–51. [3] Borbola, D., Berkei, G., Simon, B., Romanszky, L., Sersli, G., DeFee, M., Renne, W., Mangano, F., Vag, J., 2023. In vitro comparison of five desktop scanners and an industrial scanner in the evaluation of an intraoral scanner accuracy. *Journal of Dentistry*. 129, 104391. [4] Towle, I., Krueger, K.L., Hernando, R., Hlusko, L.J., 2024. Assessing tooth wear progression in non-human primates: a longitudinal study using intraoral scanning technology. *PeerJ*. 12, e17614. [5] Winkler, J., Gkantidis, N., 2020. Trueness and precision of intraoral scanners in the maxillary dental arch: an in vivo analysis. *Scientific Reports*. 10, 1172.

Poster Presentation Number 145, Session 2, Friday 14:00 - 15:30

## Ontogenetic changes in anterior diaphyseal curvature of the tibia and femur as children learn to walk bipedally

Karen R Swan<sup>1</sup>, Rachel Ives<sup>2</sup>, Louise T Humphrey<sup>1</sup>

1 - Centre for Human Evolution Research (CHER), Natural History Museum, London, UK · 2 - Vertebrates and Anthropology collections, Natural History Museum, London, UK

Diaphyseal curvature of the lower limb bones has been of great interest to anthropologists due to the large amount of variation observed between modern human groups and extinct hominin species of varying mobility patterns. While the biomechanical role of diaphyseal curvature is not fully understood in adults, it is generally thought to enhance bending predictability in response to dynamic loading conditions providing a functional benefit for those living in areas of irregular and sloped terrains [1]. Variation in diaphyseal curvature during growth, however, has received considerably less attention. Children experience notable shifts in both the direction, magnitude and frequency of lower limb loading during the timeframe of bipedal locomotor development. Transitions from crawling to upright walking and from immature to mature walking gaits has previously been reflected in long bone parameters such as the orientation of joint angles and cross-sectional geometry [2-3]. Here, we examine variation in diaphyseal curvature in the lower limb bones and consider whether this variation corresponds with changes in limb loading as children learn to walk bipedally. Matched pairs of unfused tibiae and femora were analysed from a sample of 53 documented children aged from birth to 14 years from 18<sup>th</sup> and 19<sup>th</sup> century London. Children were previously assessed for skeletal indicators of vitamin D deficiency and those exhibiting features were excluded due to known effects on long bone bending deformation [4]. 3D surface scans were generated from each long bone and virtually aligned to a common anatomical reference system using Geomagic Wrap software. The R package “morphomap” [5] was used to automatically extract cross-sections at 20%, 30%, 40%, 50%, 60%, 70% and 80% of total diaphyseal length. Centroid displacement along the anteroposterior (AP) axis was calculated using the distance from the centroid of each cross-section to the longitudinal axis defined by centroids at the distal (20%) and proximal (80%) ends of the diaphysis. This displacement was used to provide an estimate of anterior diaphyseal curvature. The results indicate that anterior centroid displacement is low at birth in both bones supporting the premise that diaphyseal curvature is developmentally acquired. Anterior centroid displacement was on average highest at the 50% location in both bones. At this location, the femur demonstrated a consistent increase in value with increasing age and walking experience. In contrast the tibia indicates a bidirectional trend. Tibia values indicated an increase in anterior curvature from birth, peaking at approximately 2 years of age around the time of toddling, which involves an irregular and unsteady walking gait. Values subsequently declined but demonstrated a gradual reversal in trend in older children. These results are consistent with previous research on femoral cross-sectional geometry indicating a restructuring of cortical bone during the timeframe of immature walking.

We are grateful to colleagues at the Natural History Museum, London and the Centre for Human Bioarchaeology, Museum of London for assistance with 3D surface scanning and the curation and collections access for the samples used in this study. This project was supported by the Calvea Foundation (KRS, LTH).

References: [1] Murray, A.A., MacKinnon, M., Carswell, T.M.R., Giles, J.W., 2023. Anterior diaphyseal curvature of the femur and tibia has biomechanical consequences during unloaded uphill locomotion. *Frontiers in Ecology and Evolution*. 11. [2] Swan, K.R., Ives, R., Humphrey, L.T., 2020. Femoral angle development and locomotor progression in children from 18th and 19th century London. *International Journal of Osteoarchaeology*. 31, 263–272. [3] Swan, K.R., Ives, R., Wilson, L.A.B., Humphrey, L.T., 2020. Ontogenetic changes in femoral cross-sectional geometry during childhood locomotor development. *American Journal of Physical Anthropology*. 173, 80–95. [4] Swan, K.R., Humphrey, L.T., Ives, R., 2022. The impact of vitamin D deficiency on cortical bone area and porosity at the femoral midsection in children from post-medieval London. *American Journal of Biological Anthropology*. 180, 272–285. [5] Profico, A., Bondioli, L., Raia, P., O'Higgins, P., Marchi, D., 2020. morphomap: An R package for long bone landmarking, cortical thickness, and cross-sectional geometry mapping. *American Journal of Physical Anthropology*. 174, 129–139.

Poster Presentation Number 146, Session 2, Friday 14:00 - 15:30

## Phalangeal cortical bone ontogeny reflects differences in age-related locomotor loading in African apes

Samar Syeda<sup>1,2,3</sup>, Sergio Almécija<sup>2,4,5,6</sup>, Ashley S. Hammond<sup>2,4</sup>

1 - Richard Gilder Graduate School, American Museum of Natural History, New York, USA · 2 - Division of Anthropology, American Museum of Natural History, New York, USA · 3 - Department of Human Origins, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 4 - New York Consortium in Evolutionary Primatology (NYCEP), New York, USA · 5 - Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Bellaterra, Spain · 6 - ICREA, Pg. Lluís Companys 23, Barcelona, Spain

The internal structure, both cortical and trabecular, of the adult hominid hand has been shown to reflect mechanical loading related to locomotion and other habitual manual behaviors [1-2]. Internal bone structure studies linking hand morphology to behaviors have focused on the trabecular bone in the carpus and metacarpus and the cortical bone in the phalanges. However, the signals are not comparable because trabecular bone remodels at a faster rate than cortical bone [3]. As such, it is possible that adult cortical bone structure reflects behaviors that occurred during ontogeny rather than remodeling due to mechanical loading occurring from habitual behaviors during adulthood [3]. Here, we investigate whether cortical bone morphology can reflect changes in mechanical loading throughout ontogeny in African apes, whose locomotor behavior undergoes significant changes during development. In the early stages of development, African ape locomotor behavior largely consists of grasping behaviors related to arboreal locomotion, which later transition into primarily terrestrial knuckle-walking behaviors in adults. This behavioral transition allows us to test whether cortical bone can accurately track changes in locomotor loading across different age stages, including adult behaviors, or if it is primarily reflecting behaviors practiced during development.

Using high-resolution micro-CT scans, we studied cortical bone thickness distribution patterns in Gorilla gorilla and Pan spp. proximal and intermediate phalanges of digits II-V across multiple ontogenetic age stages. The ontogenetic age stages included in this study consisted of young infants (N=15), old infants (N=3), juveniles (N=8), subadults (N=9), and adults (N=15), which were defined based on skeletal development and reported ontogenetic changes in locomotor behavior [4]. We used Medtool 4.5 to create external and internal surfaces of each phalanx from the micro-CT data, which were input into the R package morphomap for analysis of cortical bone distribution patterns and thickness [5].

Our results reveal distinct patterns of cortical bone distribution in the more arboreal juvenile individuals and the primarily terrestrial knuckle-walking adults. In the early stages of development, both Gorilla and Pan demonstrate the thickest cortical bone along the flexor sheath ridges, which is morphology that is consistent with flexed postures during arboreal or other grasping behaviors [2]. The cortical bone distribution patterns of subadult individuals closely resemble those observed in adult individuals of Gorilla and Pan, with cortical bone being thick along the flexor sheath ridges as well as distally, under the trochlea. This cortical bone morphology is consistent with a need for phalangeal joint stability during knuckle-walking, reflecting an increased reliance on knuckle-walking, which starts to occur in African apes within this stage of development [2]. While phalangeal cortical ontogeny of both Gorilla and Pan is consistent with developmental changes in locomotor behaviors, the timing of when those changes occur differs in both taxa. Within Gorilla, adult-like cortical bone morphology emerges at the subadult stage, whereas in Pan, it is reflected in the phalanges of juvenile individuals. These differences in the appearance of adult-like cortical morphology may reflect genus-level differences in locomotor behaviors across ontogeny [4]. This study demonstrates that ontogenetic changes in phalangeal cortical bone among African apes can reflect developmental shifts in locomotion. However, further research into internal bone structure across various skeletal elements is essential for a more comprehensive understanding of bone remodeling in response to mechanical loading, which is key for the accurate reconstruction of fossil behavioral repertoires.

We thank the Department of Mammalogy and the Microscopy and Imaging Facility at the American Museum of Natural History for access to specimens and the micro-CT scanning of specimens, the Department of Human Origins at the Max Planck Institute for Evolutionary Anthropology for access to software, and the MCIN/AEI (PID2020-116908GB-I00) and CERCA Programme for funding (S.A.).

References [1] Dunmore, C.J., Kivell, T.L., Bardo, A., Skinner, M.M., 2019. Metacarpal trabecular bone varies with distinct hand-positions used in hominid locomotion. *Journal of Anatomy*, 235, 45-66. [2] Syeda, S.M., Tsegai, Z.J., Cazenave, M., Skinner, M.M., Kivell, T.L., 2023. Cortical bone distribution of the proximal phalanges in great apes: Implications for reconstructing manual behaviours. *Journal of Anatomy*, 24, 707-728. [3] Pearson, O.M., Lieberman, D.E., 2004. The aging of Wolff's "law": ontogeny and responses to mechanical loading in cortical bone. *American journal of physical anthropology*, 125, 63-99. [4] Doran, D.M., 1997. Ontogeny of locomotion in mountain gorillas and chimpanzees. *Journal of Human Evolution*, 32, 323-344. [5] Profico, A., Bondioli, L., Raia, P., O'Higgins, P., Marchi, D., 2021. morphomap: An R package for long bone landmarking, cortical thickness, and cross-sectional geometry mapping. *American Journal of Physical Anthropology*, 174, 129-139.

Pecha Kucha Presentation, Session 2, Thursday 11:30 – 13:00

## A systematic evaluation of hominin and faunal DNA preservation in Pleistocene sediments

Merlin Szymanski<sup>1</sup>, Viviane Slon<sup>1,2,3</sup>, Louisa Jauregui<sup>1</sup>, Janet Kelso<sup>1</sup>, Matthias Meyer<sup>1</sup>, the Sediment DNA Analysis Consortium<sup>4</sup>

1 - Department of Evolutionary Genetics, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany · 2 - Department of Anatomy and Anthropology and Department of Human Molecular Genetics and Biochemistry, The Gray Faculty of Medical & Health Sciences, Tel Aviv University, Israel · 3 - The Dan David Center for Human Evolution and Biohistory Research, Tel Aviv University, Israel · 4 - All archaeologists/collaborators who provided material and context-information for their archaeological sites

Recent years have seen an increase in the use of sedimentary ancient DNA (sedaDNA) analysis to infer the past presence of humans and other species at archaeological sites, even in the absence of macroscopically visible remains. These also include Neandertals, Denisovans and modern humans, demonstrating the possibility to reconstruct past human occupations at archaeological sites at higher spatial and temporal resolution than previously imaginable [1-3]. However, to date there has been no large-scale, systematic investigation of the success rate at which hominin and faunal DNA can be recovered from archaeological sediments and of the factors that contribute to its long-term preservation.

To address this, we analyzed over 1,800 sediment samples from 133 archaeological sites with evidence of past human activity across Europe, Asia, and Africa. These sites include caves, rockshelters, and open-air locations containing deposits from the middle and late Pleistocene as well as the Holocene. The majority of samples were collected in situ following specific sedaDNA sampling protocols, but we also sampled material collected during previous excavations (archived sediments) and for other purposes, such as optical dating or tephra analysis. DNA was extracted from each sample, converted into DNA libraries and enriched for human and mammalian mitochondrial DNA (mtDNA) prior to sequencing. Sequences were then assigned to biological families, and their ancient origin was evaluated based on the presence of DNA damage patterns. For the exploration and visualization of both the genetic results and the associated archaeological context, we developed an open-source web application providing easy access to the full dataset.

We detect traces of ancient mammalian mtDNA in 400 sediment samples from 72 sites, dating back as far as 200,000 years ago, and ancient hominin mtDNA in 58 samples from 27 sites. Our dataset shows that the temporal and geographical limits of DNA preservation in sediment closely match those previously observed in ancient skeletal remains. Preliminary findings indicate that ancient DNA is best preserved in sediments from caves, followed by rock shelters and open-air sites. Although often present in only low quantities, we identified ancient hominin mtDNA at sites and in archaeological layers for which no genetic data was previously available, underlining the potential of sediment DNA analysis to broaden the scope of genetic studies on ancient populations. Different sampling protocols appear to have only a marginal effect on modern human DNA contamination, suggesting that previously collected sediments - even those not sampled with DNA in mind - remain a valuable resource for aDNA research. We hope that the empirical data presented here will improve future research design, especially with regards to the number of samples that should be analyzed and the contexts that are most promising for retrieving ancient DNA from sediment.

References [1] Slon, V., Hopfe, C., Weiß, C.L., Mafessoni, F., de la Rasilla, M., Lalueza-Fox, C., Rosas, A., Soressi, M., Knul, M.V., Miller, R., Stewart, J.R., Derevianko, A.P., Jacobs, Z., Li, B., Roberts, R.G., Shunkov, M.V., de Lumley, H., Perrenoud, C., Gušić, I., Kućan, Ž., Rudan, P., Aximu-Petri, A., Essel, E., Nagel, S., Nickel, B., Schmidt, A., Prüfer, K., Kelso, J., Burbano, H.A., Pääbo, S., Meyer, M., 2017. Neandertal and Denisovan DNA from Pleistocene sediments. *Science*. 356, 605–608. [2] Vernot, B., Zavalá, E.L., Gómez-Olivencia, A., Jacobs, Z., Slon, V., Mafessoni, F., Romagné, F., Pearson, A., Petr, M., Sala, N., Pablos, A., Aranburu, A., de Castro, J.M.B., Carbonell, E., Li, B., Krajačar, M.T., Krivoschapkin, A.I., Kolobova, K.A., Kozlikin, M.B., Shunkov, M.V., Derevianko, A.P., Viola, B., Grote, S., Essel, E., Herráez, D.L., Nagel, S., Nickel, B., Richter, J., Schmidt, A., Peter, B., Kelso, J., Roberts, R.G., Arsuaga, J.-L., Meyer, M., 2021. Unearthing Neanderthal population history using nuclear and mitochondrial DNA from cave sediments. *Science*. 372. [3] Zavalá, E.L., Jacobs, Z., Vernot, B., Shunkov, M.V., Kozlikin, M.B., Derevianko, A.P., Essel, E., de Filippo, C., Nagel, S., Richter, J., Romagné, F., Schmidt, A., Li, B., O’Gorman, K., Slon, V., Kelso, J., Pääbo, S., Roberts, R.G., Meyer, M., 2021. Pleistocene sediment DNA reveals hominin and faunal turnovers at Denisova Cave. *Nature*. 595, 399–403.

Poster Presentation Number 147, Session 2, Friday 14:00 - 15:30

## Refining the chronology of Neanderthal–*Homo sapiens* coexistence in central and southeast Europe

Frankie Tait<sup>1</sup>, Helen Fewlass<sup>2</sup>, Frido Welker<sup>3</sup>, Anna Wagner<sup>1</sup>, Geoff M. Smith<sup>1</sup>, Karen Ruebens<sup>1</sup>

1 - Archaeological Proteomics Lab, Department of Archaeology, University of Reading, UK · 2 - Department of Anthropology and Archaeology, University of Bristol, UK · 3 - Globe Institute, University of Copenhagen, Denmark

Due to advances in ancient DNA studies and recent archaeological discoveries, the coexistence between late Neanderthals and early *Homo sapiens* is now well established [1,2]. However, there is currently a limited understanding of when, where, and how frequently these groups met. In central and southeast Europe, Late Pleistocene human remains are sparse and the regional chronological framework of the Middle to Upper Palaeolithic transition is still poorly understood, with many sites lacking reliable radiocarbon chronologies.

Here, we first present a review of currently available dates for Czechia, Germany, Greece, Montenegro, Romania, Serbia and Slovakia, for the time period ca. 55,000-45,000 years ago and discuss methodological issues and gaps in the dating record. Second, we present new radiocarbon dates from bone fragments collected for ZooMS analysis as part of the wider COEXIST project, which help to refine the chronology of these sites. The bones were pre-treated using ultrafiltration and dated using accelerated mass spectrometry (AMS). High collagen yields and characteristic elemental data indicate that all of the selected samples are well-preserved and the resulting dates are reliable.

Our findings have already yielded invaluable insights at two key Romanian sites: Peștera Cioarei-Boroșteni and Nandru-Spurcată. Four new dates from Cioarei cave are significantly older than previously published dates from the same contexts. This finding necessitates redirecting our study of Neanderthal-*Homo sapiens* coexistence toward previously unconsidered stratigraphic layers. At Spurcată, published dates ranging between 30,000 and 5,475 uncal BP may be the result of poor documentation or evidence of reworking [3,4]. Our new dates fall between 45,000-40,000 cal BP, confirming the potential of this site to understand Neanderthal-*Homo sapiens* coexistence in this region.

This project is ongoing and further dating from a range of sites will refine the regional chronology of the Middle to Upper Palaeolithic transition in central and southeast Europe, providing a strong basis for studying Neanderthal-*Homo sapiens* coexistence in these areas.

References: [1] Mylopotamitaki, D., Weiss, M., Fewlass, H., Zavala, E.I., Rougier, H., Sümer, A.P., Hajdinjak, M., Smith, G.M., Ruebens, K., Sinet-Mathiot, V., Pederzani, S., Essel, E., Harking, F.S., Xia, H., Hansen, J., Kirchner, A., Lauer, T., Stahlschmidt, M., Hein, M., Talamo, S., Wacker, L., Meller, H., Dietl, H., Orschiedt, J., Olsen, J.V., Zeberg, H., Prüfer, K., Krause, J., Meyer, M., Welker, F., McPherron, S.P., Schüller, T., Hublin, J.-J., 2024. *Homo sapiens* reached the higher latitudes of Europe by 45,000 years ago. *Nature*. 626, 341–346. [2] Hajdinjak, M., Mafessoni, F., Skov, L., Vernot, B., Hübner, A., Fu, Q., Essel, E., Nagel, S., Nickel, B., Richter, J., Moldovan, O.T., Constantin, S., Endarova, E., Zahariiev, N., Spasov, R., Welker, F., Smith, G.M., Sinet-Mathiot, V., Paskulin, L., Fewlass, H., Talamo, S., Rezek, Z., Sirakova, S., Sirakov, N., McPherron, S.P., Tsanova, T., Hublin, J.-J., Peter, B.M., Meyer, M., Skoglund, P., Kelso, J., Pääbo, S., 2021. Initial Upper Palaeolithic humans in Europe had recent Neanderthal ancestry. *Nature*. 592, 253–257. [3] Cărciumaru, M., Anghelina, M., Nitu, E.-C., Cosac, M., Muratoreanu, G., Rujan, S., Banica, C., (Eds.) 2007. *Geo-archéologie du paléolithique moyen, paléolithique supérieur, épipaléolithique et mésolithique en Roumanie*, Editura Cetatea de Scaun, Cetatea de Scaun, Târgoviște. [4] Chu, W., Doboș, A., Soressi, M., 2024. Interactions in bones but not stone: Anomalous cultural transmission gaps in Romania's Middle to Upper Palaeolithic Transition. *Quaternary Science Reviews*. 329, 108546.

Poster Presentation Number 148, Session 2, Friday 14:00 - 15:30

## Breaking the limits: refining human evolution timelines with high-RESOLUTION radiocarbon dating

Sahra Talamo<sup>1</sup>, Michael Friedrich<sup>2</sup>, Florian Adolphi<sup>3</sup>, Timothy J. Heaton<sup>4</sup>, Bernhard Kromer<sup>1</sup>, Raimund Muscheler<sup>5</sup>, Mike Richards<sup>6</sup>, Laura Tassoni<sup>1</sup>, Lukas Wacker<sup>7</sup>

1 - Department of Chemistry G. Ciamician, Alma Mater Studiorum, University of Bologna Via Selmi 2, Bologna, Italy · 2 - Hohenheim Gardens, University of Hohenheim, Stuttgart, Germany · 3 - Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany · 4 - School of Mathematics, University of Leeds, UK · 5 - Quaternary Sciences, Department of Geology, Lund University, Lund, Sweden · 6 - Department of Archaeology, Simon Fraser University, Burnaby, B.C., Canada · 7 - Laboratory for Ion Beam Physics, ETH Zurich, Zurich, Switzerland

The radiocarbon method remains the cornerstone of chronological frameworks in archaeology and human evolution. Yet, many pivotal questions, such as the timing of *Homo sapiens*' dispersals and interactions with Neanderthals, have been constrained by methodological limitations, particularly during periods where the calibration curve offers low resolution. Recent innovations in radiocarbon pretreatment, AMS measurement precision, and the integration of high-resolution atmospheric datasets are transforming this landscape. For instance, recent work on subfossil larch trees from Revine (Italy) [1] demonstrates the potential of sub-decadal tree-ring records to capture fine-scale atmospheric radiocarbon fluctuations during the glacial period. These datasets highlight not only the limitations of current calibration curves beyond 14,000 years BP but also point the way forward: developing calibration curves with the resolution necessary to meet the precision demands of archaeological research between 50,000 and 15,000 cal BP.

A prominent case study that benefits from such methodological advances is the reassessment of the chronology of the Initial Upper Palaeolithic (IUP) at the Bacho Kiro Cave site (Bulgaria) [2]. Here, over 20 radiocarbon dates, obtained from well-preserved human bones and associated faunal material, were analyzed from a single stratigraphic layer (N1-I). These dates, produced with rigorous collagen pretreatment and high-precision AMS, achieve error ranges as low as  $\pm 300$  years at around 42,000  $^{14}\text{C}$  BP, a significant improvement over earlier generations of dating. By integrating these data with refined Bayesian models and an enhanced calibration curve that incorporates floating tree-ring chronologies, the site's timeline has been clarified into at least two, possibly three, temporally distinct human occupations. Notably, these refined chronologies align the occupations with specific climatic phases, revealing that *Homo sapiens*' presence at the site spanned both colder (Greenland Stadial 12) and warmer (Greenland Interstadial 11) periods. This climate-linked resolution underscores the adaptive capacity of early *Homo sapiens* and challenges earlier interpretations that assumed a single, continuous occupation, adding nuance to our understanding of their dispersal and settlement patterns in Europe.

Together, these methodological breakthroughs, high-precision dating, robust pretreatment, and improved calibration, are redefining our capacity to resolve the tempo of human evolutionary events. They pave the way for more nuanced narratives about human dispersal, cultural innovation, and interaction with changing climates across Eurasia. Looking forward, the integration of high-resolution radiocarbon data with paleoenvironmental and archaeological records holds the potential to transform our understanding of human resilience and decision-making in the face of rapid climate change during the Late Pleistocene.

This research was supported by the European Research Council (ERC) under the European Union's Horizon 2020 Research and Innovation Programme (grant agreement No. 803147, RESOLUTION, awarded to S.T.)

Reference: [1] Talamo, S., Friedrich, M., Adolphi, F., Kromer, B., Heaton, T.J., Cercatillo, S., Muscheler, R., Palčėk, D., Pelloni, E., Tassoni, L., Toniello, V., Wacker, L., 2023. Atmospheric radiocarbon levels were highly variable during the last deglaciation. *Communications Earth & Environment*. 4. [2] Talamo, S., Kromer, B., Richards, M.P., Wacker, L., 2023. Back to the future: The advantage of studying key events in human evolution using a new high resolution radiocarbon method. *PLOS ONE*. 18, e0280598.

Poster Presentation Number 149, Session 2, Friday 14:00 - 15:30

## The BRAVHO 14C chain: enhancing radiocarbon accuracy at the Upper Paleolithic site of Cotu Miculinți (Eastern Romania)

Laura Tassoni<sup>1</sup>, Mircea Anghelinu<sup>2</sup>, Marc Händel<sup>3</sup>, Andrea Picin<sup>1</sup>, Sahra Talamo<sup>1</sup>

1 - Department of Chemistry Giacomo Ciamician, Alma Mater Studiorum, Bologna University, Bologna, Italy · 2 - Faculty of Humanities, „Valahia” University, Târgoviște, Romania · 3 - Austrian Archaeological Institute, Austrian Academy of Sciences, Vienna, Austria

The area between the Eastern Carpathians and the Prut River in Romania preserves many open-air Upper Paleolithic sites, mostly linked to the Gravettian and Epigravettian technocomplexes [1,2]. Found across diverse landscapes - from the sub-Carpathian hills to the lowland steppe plateaus - these sites provide valuable insights into cultural developments and population dynamics during Marine Isotope Stage 2 (MIS 2). However, building solid chronological frameworks for open-air contexts is particularly challenging due to post-depositional processes, which significantly influence the conservation of organic remains. On the other hand, numerous anthropogenic combustion features with associated finds distributions provide dense sequences of recurrent occupation events displaying high-resolution records of changes in the material culture.

The Cotu Miculinți site, located in the Prut Basin, is a clear example of both challenges and opportunities in studying open-air paleolithic sites, especially in a period marked by climatic degradation and possible shifts in human populations [2,3]. According to the original interpretation, the archaeological sequence included seven layers assigned to the ‘Eastern Gravettian’ [4]. However, the only two radiocarbon dates currently available point to a significantly younger chronology, suggesting an attribution to the Epigravettian technocomplex [1,2].

To address these inconsistencies, new systematic excavations were combined with careful sample selection and thorough anthracological screening. A new series of radiocarbon measurements was performed at the BRAVHO lab (Bologna Radiocarbon Laboratory for Human Evolution, University of Bologna), where particular attention was paid to the challenges of open-air sites like Cotu Miculinți. While the methodological protocols followed established best practices, the lab’s integrated workflow, covering every step from chemical pretreatment to graphite preparation and AMS submission [5], ensures minimal risk of contamination and high reproducibility.

The meticulous approach resulted in high-precision dating outcomes more consistent with the site's stratigraphy and cultural sequence, suggesting that the occupational sequence at Cotu Miculinți may extend by up to 6,000 years. However, further investigations are required, and additional 14C dates are already in progress. Cotu Miculinți stands as a clear demonstration of how meticulous laboratory protocols can fundamentally improve the reliability of archaeological chronologies. In contexts where post-depositional processes compromise dating accuracy, such precision becomes essential. By providing a robust and stratigraphically coherent chronological framework, this study not only advances the understanding of the site itself but also strengthens the integration of Eastern European data into broader narratives of human adaptation, mobility, and cultural change during the Late Pleistocene.

This project is funded by FARE (Framework per l'attrazione ed il rafforzamento delle eccellenze per la Ricerca in Italia – III edizione), through the project "Evaluate the precision of time in Human Evolution adopting spectrometric methods for archaeological bones – EURHOPE" (Prot. R20L4N7MS5, CUP J53C2200374000), awarded to Sahra Talamo.

References: [1] Anghelinu, M., Niță, L., Murătoareanu, G., 2018. Le Gravettien et l'Épigravettien de l'Est de la Roumanie: une réévaluation. *L'Anthropologie*. 122, 183–219. [2] Anghelinu, M., Niță, L., Veres, D., Hambach, U., Händel, M., Cordoș, C., Ilic, M., Murătoareanu, G., 2021. Break vs. continuity: Techno-cultural changes across the LGM in the Eastern Carpathians. *Quaternary International*. 581–582, 241–257. [3] Maier, A., Stojakowits, P., Mayr, C., Pfeifer, S., Preusser, F., Zolitschka, B., Anghelinu, M., Bobak, D., Duprat-Oualid, F., Einwögerer, T., Hambach, U., Händel, M., Kaminská, L., Kämpf, L., Lanczont, M., Lehmkuhl, F., Ludwig, P., Magyari, E., Mroczek, P., Nemergut, A., Nerudová, Z., Niță, L., Polanská, M., Poltowicz-Bobak, M., Rius, D., Römer, W., Simon, U., Škrdl, P., Újvári, G., Veres, D., 2021. Cultural evolution and environmental change in Central Europe between 40 and 15 ka. *Quaternary International*. 581–582, 225–240. [4] Brudiu, M., 1980. Cercetări arheologice în stat, iunea paleolitică de la Cotu Miculinți, i. jud. Botosani, Materiale și Cercetări Arheologice XIV, pp. 5–12. [5] Tassoni, L., Kromer, B., Friedrich, R., Wacker, L., Cattani, M., Friedrich, M., Paleček, D., Pelloni, E., Peng, K., Thomas, M.E., Talamo, S., 2023. Safe preparation and delivery of Graphite targets for 14C analysis: procedures of BRAVHO Lab at Bologna University. *Radiocarbon*. 66, 1368–1378.

Poster Presentation Number 150, Session 2, Friday 14:00 - 15:30

## Preliminary analyses of the vertebral trabecular bone structure of the *Australopithecus* StW 573 (“Little Foot”) from Sterkfontein (South Africa)

Charlotte E.G. Theye<sup>1,2</sup>, Jason L. Heaton<sup>3,4</sup>, Dominic Stratford<sup>5,6</sup>, Ron J. Clarke<sup>4</sup>, Robin Crompton<sup>7</sup>, Kristian J. Carlson<sup>4,8</sup>, Tea Jashashvili<sup>8,9</sup>, Travis R. Pickering<sup>4,10</sup>, Amélie Beaudet<sup>1,5,11</sup>

1 - Laboratoire de Paléontologie, Évolution, Paléoécosystèmes et Paléoprimatologie, UMR 7262 CNRS & Université de Poitiers, France · 2 - Department of Anatomy, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa · 3 - Department of Biology, University of Alabama at Birmingham, USA · 4 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa · 5 - School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa · 6 - Department of Anthropology, Stony Brook University, Stony Brook, New York, USA · 7 - Department of Rheumatology, Aintree University Hospital NHS Trust, Liverpool, England · 8 - Division of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, Los Angeles, USA · 9 - Department of Geology and Paleontology, Georgian National Museum, Tbilisi, Georgia · 10 - Department of Anthropology, University of Wisconsin, Madison, USA · 11 - Department of Archaeology, University of Cambridge, Cambridge, United Kingdom

The vertebral column plays a crucial role in posture, locomotion, and overall trunk stability and mobility, making it a key region for reconstructing hominin palaeobiomechanical environments [1]. Internal bone architecture, particularly of the trabecular bone, of the vertebral body reflects biomechanical loadings, which have proven relevant for discriminating locomotor behaviour in great apes [2].

StW 573 (“Little Foot”), a nearly complete *Australopithecus* skeleton discovered in Sterkfontein Member 2 (South Africa), is notable for its exceptional state of preservation and completeness, including 16 preserved vertebrae, as well as for its age, ca. 3.67 million years, making it one of the oldest *Australopithecus* specimens in the southern African fossil record [3]. In this context, our study aims to investigate the unreported internal bone structure of StW 573 vertebrae. In addition to describing their internal conditions, this project is conducting a comparative assessment of various textural and structural parameters of the trabecular bone to identify potential function-related signals. Here we present preliminary results focusing on one of the vertebrae of StW 573.

The vertebrae of StW 573 were scanned at the Evolutionary Studies Institute (South Africa) using micro-CT. Our exploration of the micro-CT scans revealed that the internal structure of the vertebrae is filled with dense sediment but still presents clear trabecular networks. Our preliminary results identified one of the lower thoracic vertebrae, isolated from the surrounding matrix and other vertebrae, with a trabecular network that is particularly well-preserved. Although plastic deformation appeared to have affected the posterior region of this vertebra, the body remains nearly intact. A channel-like structure is observed crossing laterally through the body, which could be interpreted as post-mortem insect traces [4], and excluded from the trabecular analysis. Accordingly, we focused our preliminary analysis of the vertebral trabecular bone of StW 573 on this vertebra.

The trabecular network was further analysed quantitatively within the vertebral body of the vertebra using textural and structural parameters. The comparative sample included micro-CT scans of StW 41, an *Australopithecus* vertebral series from Sterkfontein, comprising two lower thoracic vertebrae [5], as well as lower thoracic vertebrae from 4 extant *Homo*, 4 *Pan* and 4 *Papio* curated at the University of Pretoria (South Africa) and the Royal Museum for Central Africa (Belgium), all with fully scanned columns. Trabecular bone volume fraction BV/TV (%), degree of anisotropy (DA), trabecular thickness (Tb.Th, mm) and spacing (Tb.Sp, mm) were quantified within standardised volumes of interest centred in the vertebral bodies.

The trabecular network in this vertebra of StW 573 is relatively dense and thicker than in *Pan* or *Papio*, with BV/TV and Tb.Th values closer to those of *Homo*. Conversely, the trabeculae are less spaced (well packed) and more organised than in *Homo*, with Tb.Sp and anisotropy values more consistent with *Pan*. When compared to StW 41, the StW 573 thoracic vertebra shows a denser trabecular structure with thicker and more organised trabeculae.

This first quantitative analysis of the inner bone structure of one of StW 573 vertebrae, and its preliminary results, reinforces the potential of vertebral trabecular bone as a biomechanical signal. Ongoing analyses of the remaining vertebrae of StW 573 vertebral column will help place these initial results within a broader anatomical and functional context. If variation in the properties of the trabecular bone enclosed in the vertebral body indeed provides a functional signal, our findings might contribute to the ongoing discussion on the behavioural diversity among early hominins, and more particularly within the *Australopithecus* assemblage of Sterkfontein.

References: [1] Lovejoy, C.O., 2005. The natural history of human gait and posture. *Gait & Posture*. 21, 95–112. [2] Cotter, M.M., Simpson, S.W., Latimer, B.M., Hernandez, C.J., 2009. Trabecular microarchitecture of Hominoid thoracic vertebrae. *The Anatomical Record*. 292, 1098–1106. [3] Clarke, R.J., 2019. Excavation, reconstruction and taphonomy of the StW 573 *Australopithecus prometheus* skeleton from Sterkfontein Caves, South Africa. *Journal of Human Evolution*. 127, 41–53. [4] Odes, E.J., Parkinson, A.H., Randolph-Quinney, P.S., Zipfel, B., Jakata, K., Bonney, H., Berger, L.R., 2017. Osteopathology and insect traces in the *Australopithecus africanus* skeleton StW 431. *South African Journal of Sciences* 113, 1–7. [5] Theye, C.E.G., Stratford, D., Beaudet, A., 2025. Investigating the vertebral trabecular bone structure of the *Australopithecus* vertebral series StW-8/41 from Sterkfontein (South Africa). Program of the 94th Annual Meeting of the American Association of Biological Anthropologists, 2025. *American Journal of Biological Anthropology*. 186.

Poster Presentation Number 151, Session 2, Friday 14:00 - 15:30

## Sex estimation of Late Pleistocene ungulates at Axlør cave using palaeoproteomics

Leire Torres-Iglesias<sup>1</sup>, Louise Le Meillour<sup>1</sup>, Gaudry Troché<sup>1</sup>, Jesper V. Olsen<sup>2</sup>, Ana B. Marín-Arroyo<sup>3</sup>, Frido Welker<sup>1</sup>

1 - Globe Institute, University of Copenhagen, Copenhagen, Denmark · 2 - Novo Nordisk Foundation Center for Protein Research, University of Copenhagen, Copenhagen, Denmark · 3 - EvoAdapta Group, Dpto. Ciencias Históricas, Universidad de Cantabria, Santander, Spain

Neanderthal subsistence strategies have been extensively studied with the aim of evaluating different aspects, including whether they followed selective hunting strategies, the taxonomic diversity of exploited fauna and the seasonality of site occupations, among others [1-2]. However, the sex of the ungulates hunted by these hominin groups has been marginally explored due to the general lack of sex-based data of Pleistocene zooarchaeological remains. The highly fragmented nature of Palaeolithic faunal assemblages usually prevents taking osteometric measurements that allow sex determination based on sexual dimorphism. As a result, valuable information to disentangle the type of herds targeted by these Palaeolithic societies and the reasons behind its hunting behaviour is being lost. The application of biomolecular techniques to faunal materials has great potential to overcome some of the limitations of traditional zooarchaeology. In this sense, ancient protein analysis can be used to identify biological sex through the characterization of amelogenin X and Y proteins isoforms. This method has been proven successfully applicable for sex estimation in humans and some other mammalian species [3].

Here we present the biological sex determination for some of the main ungulates families present in the archaeological record: Bovidae, Equidae, Cervidae, and Suidae. First, we performed a pilot study with approximately 12 modern specimens for each family with known genetic sex, maintaining a roughly equal ratio of males to females. Enamel protein extractions were conducted using a digestion-free acid solubilization protocol on enamel powder, followed by LC-MS/MS analysis. Most of the modern reference specimens were confidently assigned to their corresponding sex, with the exception of Suidae, which, due to biological factors, exhibit no variation between the X and Y amelogenin proteins. Then, we applied the sex determination using amelogenin analysis on 16 teeth of *Bos/Bison*, *Equus ferus* and *Cervus elaphus* recovered from four Mousterian levels at Axlør cave (northern Iberia), which has yielded a well-preserved Middle Palaeolithic sequence with human occupations evidences from the MIS5-3 [4].

Differences in behaviour and physical characteristics between males and females have been shown as relevant factors in hunting preferences of modern hunter-gatherer societies. In the same way, sex may also have influenced the prey choice procurement by Pleistocene hunter-gatherer groups. Therefore, integrating palaeoproteomic and zooarchaeological data will improve our understanding of hominin subsistence behaviour and hunting strategies.

This research has received funding from the Spanish Ministerio de Ciencia e Innovación - Agencia Estatal de Investigación (PID2021-125818NB-I00 NEWINDS project awarded to A.B.M.), the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme, grant agreement no. 948365 (PROSPER, awarded to F.W.) and the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grants agreement no. 101148342 (PALEOHUNTERS, awarded to L.T.I.) and no. 101062449 (ICARHUS, awarded to L.L.M.).

References: [1] Rendu, W., 2022. Selection versus opportunism: A view from Neanderthal subsistence strategies. In: Romagnoli, F., Rivals, F., Benazzi, S., (Eds.), *Updating Neanderthals: Understanding Behavioural Complexity in the Late Middle Palaeolithic*, Elsevier, Amsterdam, p. 109–122. [2] Marín, J., Daujeard, C., Saladié, P., Rodríguez-Hidalgo, A., Vettese, D., Rivals, F., Boulbes, N., Crégut-Bonnoure, E., Lateur, N., Gallotti, R., Arbez, L., Puaud, S., Moncel, M.-H., 2020. Neanderthal faunal exploitation and settlement dynamics at the Abri du Maras, level 5 (south-eastern France). *Quaternary Science Reviews*. 243, 106472. [3] Welker, F., Ásmundsdóttir, R.D., Mylopotamitaki, D., Torres-Iglesias, L., Villa-Islas, V., Le Meillour, L., Fagernäs, Z. 2025. Paleoproteomic contributions, and current Limitations, to understanding Middle and Late Pleistocene human evolution. *PaleoAnthropology* 2, early view. [4] Demuro, M., Arnold, L.J., González-Urquijo, J., Lazuen, T., Frochoso, M., 2023. Chronological constraint of Neanderthal cultural and environmental changes in southwestern Europe: MIS 5–MIS 3 dating of the Axlør site (Biscay, Spain). *Journal of Quaternary Science*. 38, 891–920.

Poster Presentation Number 152, Session 2, Friday 14:00 - 15:30

## A 3D geo-morphometric and classical study of the human metacarpal found at the Ruidera site

Tomás Torres-Medina<sup>1,3</sup>, Carlos A. Palancar<sup>1</sup>, Sara Díaz-Pérez<sup>2</sup>, Olivia C. Motong-Asue<sup>3</sup>, Antonio Rosas<sup>1</sup>, Daniel García-Martínez<sup>3,4,5</sup>

1 - Grupo de Paleoantropología, Departamento de Paleobiología, Museo Nacional de Ciencias Naturales (MNCN - CSIC) · 2 - Institute of Archaeology, University of Wrocław, Wrocław, Poland · 3 - Physical Anthropology Unit, Biodiversity, Ecology and Evolution Department, Universidad Complutense de Madrid, Madrid, Spain · 4 - Laboratory of Forensic Anthropology, Centre for Functional Ecology, Department of Life Sciences, Universidade de Coimbra, Coimbra, Portugal · 5 - CENIEH (National Research Center on Human Evolution), Paseo de la Sierra de Atapuerca 3, Burgos, Spain

During the 2023 and 2024 campaigns, two human metacarpals (RVH-9; RVH-22) were unearthed at the Ruidera site (dated to approximately 350 ka [1]). In the absence of a taxonomic association of the remains, we tried to identify taxonomical similarities through a classical anthropometric and a 3D geometric-morphometric (3DGM) study.

The study of classical measures was based on data obtained from 30 *Homo sapiens* and 4 *Homo neanderthalensis* individuals. In addition, classical measurements were obtained from the bibliography corresponding to the Skhul [2], Tabun [2], Shanidar [3], Sima de los Huesos and Gran Dolina [4] sites (NMI=43). For the 3DGM study, 28 *H. sapiens*, 8 *H. neanderthalensis*, 1 *H. sapiens* fossil and 1 *Homo naledi* were measured (NMI=38).

RV-9: Fragmented right second metacarpal. The preservation of the diaphysis and the entire distal articular head is a notable feature. The bone exhibits a substantial, wide, and low head, a trait that is not typical in modern humans, Neanderthals or Sima de los Huesos individuals but shown in earlier *Homo* groups [5].

RV-22: Fragment of Metacarpus 2/3 right. It only preserves the distal articular surface, which has similar characteristics to RVH-9, the rest of the bone is missing.

RV has in its classic measurements a low and wide head similar to *Homo antecessor* and Skhul, a trait that does not appear in the rest of the species, proving a big difference with sapiens, neanderthals and Sima de los Huesos. The body of all the metacarpals studied is similar in shape and indexes, with no outlier in the sample. In general, RV stands out for its large size in bone measurements, which is confirmed by the study of centroid size, being this individual superior in size to the whole sample studied, except for some male sapiens individuals.

In shape space RVH-9 lies within the Neanderthal variation, close to the sapiens distribution. However, in form space RV-9 lies outside the Neanderthal variability, at the edge of the sapiens distribution. Applying a between groups PCA revealed a remarkable differentiation in the Neanderthal group, despite the significant variability of the populations and chronologies studied. The other species were associated with the sapiens group, characterized by a very homogeneous population studied.

This association between the species studied reflects how Neanderthals differs from the rest of the sample, where the most western and modern individuals are slightly distant from the eastern and ancient populations and from the rest of the species studied. RV-9 is outside this association, indicating that it does not present Neanderthal characteristics in its metacarpal. Ruidera, however, when applying a cluster of Procrustes distances, is located at the base of the speciation of both species, demonstrating the archaic characteristics it possesses.

In summary, we could consider Ruidera as an individual outside the purely Neanderthal characteristics and that presents differences with that species. The same occurs in other sites of the European Middle and Lower Pleistocene such as Gran Dolina, Petralona or Sima de los Huesos.

This research is funded by Leakey Foundation project ID: 45148 (2024-2025) entitled "Paleoanthropological investigation at Ruidera-Los Villares: Deciphering Middle Pleistocene Enigma in Western Europe"; and also, by Fundación PALARQ project entitled "Desvelando la Cronología del Pasado Humano: Análisis Multimétodo de Datación en el Yacimiento de Ruidera-Los Villares, Pleistoceno Medio". We acknowledge the neighbours and institutions from Ruidera for their hospitality as well as Junta de Comunidades de Castilla-La Mancha and Parque Natural de las Lagunas de Ruidera for awarding the permits for the excavation. We also want to acknowledge the entire excavation team for their great and selfless work. Ministerio de Ciencia e Innovación. PID2021-122356NB-I00, PID2020-115854GB-I00

References: [1] García Martínez, D., Duval, M., Zhao, J., Feng, Y., Wood, R., Huguet, R., Cifuentes-Alcobendas, G., Palancar, C.A., Moya-Maleno, P.R., 2022. Los Villares locality (Ruidera, Castilla-La Mancha, Spain): a new Middle Pleistocene fossil assemblage from the Southern Iberian Plateau with possible evidence of human activity. *Cuaternario y Geomorfología*. 36, 7–35. [2] Garrod, D. A. (1980). The stone age of Mount Carmel: report of the Joint Expedition of the British School of Archaeology in Jerusalem and the American School of Prehistoric Research, 1929-1934. AMS Press. [3] Trinkaus, E. (2014). The shanidar neandertals. Academic Press. [4] Lorenzo, C., Arsuaga, J.L., Carretero, J.M., 1999. Hand and foot remains from the Gran Dolina Early Pleistocene site (Sierra de Atapuerca, Spain). *Journal of Human Evolution*. 37, 501–522. [5] Musgrave, J.H., 1971. How Dextrous was Neanderthal Man? *Nature*. 233, 538–541.

Poster Presentation Number 153, Session 2, Friday 14:00 - 15:30

## Growing up human? Ontogenetic insights from the femur of Turkana Boy

**Benjamin Tournan<sup>1</sup>, Alessandro Urciuoli<sup>2</sup>, Guillermo Bravo Morante<sup>1</sup>, Christine Tardieu<sup>3</sup>, Tea Jashashvili<sup>4,5</sup>, Christopher Ruff<sup>6</sup>, Martin Haeusler<sup>1</sup>**

1 - Institute of Evolutionary Medicine, University of Zurich, Switzerland · 2 - Department of Paleontology, University of Zurich, Switzerland · 3 - Muséum National d'Histoire Naturelle, 55 rue Buffon, 75005 Paris, France · 4 - Division of Integrative Anatomical Sciences, Keck School of Medicine, University of Southern California, Los Angeles, USA · 5 - Department of Radiology, Keck School of Medicine, University of Southern California, USA · 6 - Center for Functional Anatomy and Evolution, Johns Hopkins University School of Medicine, Baltimore, USA

KNM-WT 15000 (Turkana Boy) [1], the remarkably complete 1.5-million-year-old juvenile *Homo erectus* skeleton from Nariokotome, Kenya, is a key specimen for understanding growth and development in early *Homo*. Despite its completeness, fundamental questions persist regarding the tempo and mode of skeletal maturation in this individual, and by extension in *H. erectus* in general. Particularly striking is the discrepancy between its chronological age estimates based on dental histology (7.6–8.8 years) and skeletal maturation indicators that suggest a significantly older age of between 13 (epiphyses of the distal humerus) to 15 years (width-to-depth proportions of the distal femoral epiphyses) based on modern human standards [2,3]. This gap raises key questions about how much KNM-WT 15000 would have grown until adulthood [4] and whether *H. erectus* followed a modern human growth trajectory or displayed a heterochronic pattern that decoupled dental and postcranial development. Since epiphyseal morphology directly reflects skeletal maturation, it offers a promising, yet underutilized, source of independent developmental data that provide a measure for the remaining growth potential. However, the distal femoral epiphysis of this fossil is heavily deformed and compressed which might have impacted previous inferences about body size and growth.

Here, we virtually reconstruct the distal femoral epiphysis of KNM-WT 15000 based on micro-CT scans of the left and right fossil distal femoral epiphyses and mirror-image reconstruction techniques. Building on previous studies to compare the distal femoral epiphysis [2], we increase the comparative sample size and employ our new digital reconstruction to situate Turkana Boy within an ontogenetic series of 83 modern humans aged 8 to 18 years. In addition, the right femoral head and greater trochanter were compared to the same modern human ontogenetic series. Using Deformetrica 4.3 (a deformation-based statistical shape analysis software), we show that the KNM-WT 15000 femur consistently align with individuals in the early adolescence range of the modern human ontogenetic series. Our preliminary results indicate that the shape of the femoral head and greater trochanter best corresponds to that of modern human individuals between 12.5 and 13.3 years of age, which is in line with previous analyses of the epiphyseal maturation of the elbow joint [1], and suggests that he would have grown for an additional 5 to 6 years until reaching adult stature (see [4]; cf. [5]). We also show that age estimation based on femoral epiphyseal shape is a valid approach using this landmark-free method, as evidenced by the structured variation observed among modern humans. Our findings offer a novel, shape-based line of evidence contributing to the ongoing debate on growth patterns in early *Homo*. By combining traditional morphometric approaches based on linear measurements with advanced deformation-based shape analysis, we demonstrate the potential of epiphyseal morphology to estimate developmental age in fossil hominins. Furthermore, our new reconstruction of the distal femur of KNM-WT 15000 provides a critical anatomical element for refining estimates of his stature at death and assessing alternative growth trajectories.

Financial support was provided by the Swiss National Science Foundation (SNSF) grant No. 10.001.200 and National Science Foundation (NSF) grant No. 24361491

References: [1] A. Walker, R. Leakey (Eds.), 1993. The Nariokotome *Homo erectus* Skeleton, Springer, Berlin. [2] Tardieu, C., 1998. Short adolescence in early hominids: Infantile and adolescent growth of the human femur. *American Journal of Physical Anthropology*. 107, 163–178. [3] Dean, M.C., Smith, B.H., 2009. Growth and Development of the Nariokotome Youth, KNM-WT 15000. In: Grine, F.E., Fleagle, J.G., Leakey, R.E. (Eds.) *The First Humans – Origin and Early Evolution of the Genus Homo*. Springer, Dordrecht, p. 101–120. [4] Ruff, C.B., Burgess, M.L., 2015. How much more would KNM-WT 15000 have grown? *Journal of Human Evolution*. 80, 74–82. [5] Cunningham, D.L., Graves, R.R., Wescott, D.J., McCarthy, R.C., 2018. The effect of ontogeny on estimates of KNM-WT 15000's adult body size. *Journal of Human Evolution*. 121, 119–127.

Poster Presentation Number 154, Session 2, Friday 14:00 - 15:30

## Hominin dispersal in the changing landscapes of the East African Rift

Raphael Tournier<sup>1</sup>, Sandrine Prat<sup>2</sup>, Jean-Renaud Boisserie<sup>3,4</sup>, Doris Barboni<sup>5</sup>, Nicolas Bellahsen<sup>6</sup>, Cecile Doubre<sup>7</sup>, Raphael Pik<sup>8</sup>, Tristan Salles<sup>9</sup>, Pierre Sepulchre<sup>10</sup>, Christel Tiberi<sup>11</sup>, Laurent Husson<sup>1</sup>

1 – ISTerre, CNRS Université Grenoble-Alpes · 2 – HNHP, CNRS MNHN · 3 - CFEE, CNRS & Ambassade de France, Addis

Abeba, Ethiopie · 4 - PALEVOPRIM, CNRS & Université de Poitiers · 5 - UAR 3330 Savoirs et Mondes Indiens, Institut Français de

Pondichéry, Pondichéry, Inde · 6 - ISTEP, CNRS Université Paris-Sorbonne · 7 - EOST, CNRS Université Strasbourg · 8 - CRPG

CNRS, Université de Lorraine · 9 - School of Geosciences, The University of Sydney, Sydney, Australia · 10 – LSCE, CNRS,

Université Paris Saclay · 11 - Geosciences Montpellier, CNRS Université de Montpellier

Understanding how environmental (geologic and climatic) dynamics shaped hominin dispersal before 1 Ma requires integrated reconstructions of the East African Rift's evolving landscapes. In this study, we develop a time-continuous model of topographic and environmental change, accounting for tectonics, volcanism, mantle-driven dynamic topography, climate, vegetation and physiography. These reconstructions will then be used to constrain hominin dispersal and evolution using macro-ecological models.

We present a new approach to reconstructing elevation changes through time by disentangling the contributions of dynamic topography (the deflections of the topography due to the vertical stresses imposed by the underlying mantle convection), isostatic adjustments (tectonic uplift and subsidence), and episodic volcanic activity that partially and episodically reshape the surface of the Earth. The dynamic component is obtained by comparing and electing the most appropriate model of global dynamic topography - albeit at a regional scale for this study. The isostatic component is reconstructed by a reasoned interpretation of the amplitude of tectono-volcanic events based on comprehensive compilations. These reconstructions form the foundation for an original regional elevation model that is continuous over time, and which will serve in our analysis of the climatic, physiographic and, more generally, environmental conditions likely impacting hominin dispersal across the region.

Preliminary results highlight significant spatio-temporal variation in elevation and surface transformation, including phases of basaltic resurfacing, the formation of East African Rift shoulders and the Afar stratoid volcanic phase. Particular attention has been paid to the East African Rift System (EARS), in line with its central role in paleoanthropological research, although the study encompasses the entire African continent, with the aim of constraining and detecting the broader potential dynamics of hominin spatial occupation.

References: [1] Prat, S., 2018. First hominin settlements out of Africa. Tempo and dispersal mode: Review and perspectives. *Comptes Rendus Palevol*. 17, 6–16. [2] Husson, L., Salles, T., Lebatard, A.-E., Zerah, S., Braucher, R., Noerwidi, S., Aribowo, S., Mallard, C., Carcaillet, J., Natawidjaja, D.H., Bourlès, D., Aumaitre, G., Bourlès, D., Keddadouche, K., 2022. Javanese *Homo erectus* on the move in SE Asia circa 1.8 Ma. *Scientific Reports*. 12. [3] Faccenna, C., Glišović, P., Forte, A., Becker, T.W., Garzanti, E., Sembroni, A., Gvirtzman, Z., 2019. Role of dynamic topography in sustaining the Nile River over 30 million years. *Nature Geoscience*. 12, 1012–1017. [4] Rime, V., Foubert, A., Ruch, J., Kidane, T., 2023. Tectonostratigraphic evolution and significance of the Afar Depression. *Earth-Science Reviews*. 244, 104519. [5] Gibert, C., Vignoles, A., Contoux, C., Banks, W.E., Barboni, D., Boisserie, J.-R., Chavasseau, O., Fluteau, F., Guy, F., Noûs, C., Otero, O., Sepulchre, P., Souron, A., Ramstein, G., 2022. Climate-inferred distribution estimates of mid-to-late Pliocene hominins. *Global and Planetary Change*. 210, 103756.

Poster Presentation Number 155, Session 2, Friday 14:00 - 15:30

## Spatial distribution and large prey biomass during the Late Pleistocene in the Upper Lozoya River Valley (Madrid, Spain)

Beatriz Trejo<sup>1,2</sup>, Marco Vidal-Cordasco<sup>3</sup>, Ana B. Marín-Arroyo<sup>3</sup>, Enrique Baquedano<sup>4,5</sup>, Juan Luis Arsuaga<sup>1,2</sup>, Theodoros Karampaglidis<sup>6,7</sup>, Guillermo Rodríguez-Gómez<sup>1,2</sup>

1 - Departamento de Geodinámica, Estratigrafía y Paleontología, Universidad Complutense de Madrid, C/ José Antonio Novais 12, Madrid, Spain · 2 - Centro UCM-ISCIH de Evolución y Comportamiento Humanos, Avd. Monforte de Lemos 5, Pabellón 14, Madrid, Spain · 3 - Grupo de I+D+i EvoAdapta (Evolución Humana y Adaptaciones durante la Prehistoria), Departamento de Ciencias Históricas, Universidad de Cantabria, Santander, Spain · 4 - Museo Arqueológico y Paleontológico de la Comunidad de Madrid, Plaza de las Bernardas s/n, Alcalá de Henares, Madrid, Spain · 5 - Institute of Evolution in Africa (IDEA), Universidad de Alcalá, C/ Covarrubias 36, Madrid 28010, Spain · 6 - Departamento de Ingeniería Geológica y Minera, Universidad de Castilla-La Mancha, Toledo, Spain · 7 - Department of Archaeology, Hebrew University of Jerusalem, Jerusalem, Israel

In the upper valley of the Lozoya River (Madrid, Spain), close to the municipality of Pinilla del Valle, are the Calvero de la Higuera sites, which show evidence of Neanderthal settlements. This region is characterized by a semi-closed ecosystem, surrounded by high-altitude mountains with only one possible exit in the northeastern area. This study aims to reconstruct the environment inhabited by these humans during the Late Pleistocene and to evaluate the animal resources available to the Neanderthals by modeling the potential distribution of nine large herbivorous mammals (*Bos primigenius*, *Rupicapra pyrenaica*, *Capreolus capreolus*, *Cervus elaphus*, *Dama dama*, *Sus scrofa*, *Equus ferus*, *Stephanorhinus hemitoechus*, and *Castor fiber*) that were present in the upper valley of the Lozoya River because they are recorded at the Cueva del Camino site (~90 ka). We used species distribution models (SDMs) based on fossil occurrence data and paleoclimatic reconstructions to estimate their distributions. These models incorporated variables such as temperature, precipitation, elevation, and biome type, and were built using an ensemble of four SDM algorithms: GLM, GAM, Maxent, and BART. As a result, potential distribution maps were obtained for each species, representing areas of greater or lesser habitat suitability or species presence probability, with values ranging from 0 to 1, where 1 indicates locations with the highest habitat suitability or presence probability. From these maps, we inferred the population density of each species by integrating both habitat suitability and Net Primary Productivity (NPP). We then used these densities along with the species' body mass to estimate the prey biomass that the upper valley of the Lozoya River could support, helping us assess whether these would have been sufficient to sustain Neanderthals groups. The results suggest a small number of Neanderthals in the valley, which would lead us to expect that they might have used the area as a hunting ground, taking advantage of both the semi-closed ecosystem and its enclosed topographical features.

Poster Presentation Number 156, Session 2, Friday 14:00 - 15:30

## **Munyama Cave (Uganda): archaeological and environmental dynamics in the Late Pleistocene of Equatorial Africa**

**Christian A. Tryon<sup>1</sup>, Alice Leplongeon<sup>1,2</sup>, Veerle Rots<sup>3</sup>, Guilhem Maruan<sup>4</sup>, Iris Querenet Onfroy de Breville<sup>1</sup>,**

**Els Cornelissen<sup>5</sup>**

1 - University of Connecticut · 2 - CNRS (UMR 7194) · 3 - Université de Liège · 4 - CNRS (UMR 5608) · 5 - Royal Museum of Central Africa

Lake Victoria Nyanza is a key source of water for Nile River, is the continent's largest lake, lies at the intersection of several biomes, and today supports some of Africa's densest human settlements. However, the size of the lake, its connection with the Nile basin, and the nature of the surrounding habitats and human societies have fluctuated throughout the Quaternary. Generally drier habitats throughout much of the Late Pleistocene resulted in a severely diminished or at times possibly absent lake that was replaced instead by a Serengeti-like grassland occupied by highly mobile foragers with Middle Stone Age (MSA) technologies, best documented from about ~100,000-36,000 years ago (~100-36 ka). These grasslands were in turn gradually replaced by woodlands, forest, and a fringe of edible cattails or bulrush (*Typha* sp.) as lake level rose and connections with the Nile were reestablished around ~13 ka.

Munyama Cave, located on Uganda's Buvuma Island immediately south of the outlet of the Victoria Nile, is unique among the archaeological sites in the region for sampling the lake's last drying up and refilling episodes from ~17-10 ka, and can therefore provide a model for past shifts from drier to more humid conditions. Although dominated by a lithic technology consisting of the bipolar reduction of quartz and the manufacture of backed microliths, other aspects of Later Stone Age (LSA) assemblage are unusual, particularly the large numbers of tool for grinding and percussive tasks, as well as what appears to be some of the densest concentrations of worked ochre from an Equatorial African site. These behavioral shifts immediately precede others seen in the early Holocene, including changes in residential patterns (longer-term, possibly multi-seasonal lakeshore occupations), changes in diet (increased reliance on aquatic resources), and changing in methods of storage, cooking, and display with the early advent and adoption of (Kansyore) ceramics.

Munyama Cave was excavated in 1968 but little was ever published about the site other than radiocarbon dates. As an initial step in better understand social and technological changes to the daily lives of terminal Pleistocene communities in the Lake Victoria Nyanza basin and how these related to major changes in the local environment, we have begun reassessing the site's archival and artifact collections, which are housed at the Royal Museum for Central Africa in Tervuren, Belgium. The archival studies have allowed us to reconstruct the nature of the excavation, and to provide context for the recovered materials. To date, we have focused on a lithic technological analysis of (1) the production and use of quartz backed microliths, (2) the substantial number of large stone tools transported to the site that were modified by percussion and grinding, and (3) the site's rich collection of anthropogenically modified 'ochre.' Discussions of these kinds of artifacts are often unnecessarily restricted to discussions of 'behavioral modernity.' Instead, we use the Munyama Cave collection to document how communities in the Pleistocene employed these social and subsistence technologies in their daily lives in a way few other sites from this region can, and to situate it as part of a longer-term trajectory of behavioral shifts across environmental changes in the later Pleistocene.

This work was funded in part by the Fonds Wetenschappelijk Onderzoek—Vlaanderen (FWO)/Research Foundation—Flanders, KU Leuven, and the University of Connecticut.

Poster Presentation Number 157, Session 2, Friday 14:00 - 15:30

## Dental microwear textures of Plio-Pleistocene bovids from Ledi-Geraru and Hadar, Ethiopia

Peter S. Ungar<sup>1</sup>, Christopher J. Campisano<sup>2</sup>, Andrew G. Kirkpatrick<sup>1</sup>, Ignacio A. Lazagabaster<sup>3</sup>, Kaye E. Reed<sup>2</sup>, Joshua R. Robinson<sup>4</sup>, John Rowan<sup>5</sup>, Jessica R. Scott<sup>6</sup>

1 - University of Arkansas · 2 - Arizona State University · 3 - Centro Nacional de Investigación sobre Evolución Humana · 4 - Boston University · 5 - University of Cambridge · 6 - University of Arkansas Little Rock

The interval spanning the Plio-Pleistocene transition has long been considered pivotal to the origin and early evolution of our genus. Some researchers have associated a pulse of new taxa, including *Homo*, with climate changes marked by high-latitude glacial cycles and a trend toward cooler, drier, and more seasonal conditions at this time. To work out the details, much attention has focused on the lower Awash Valley in the Afar depression of Ethiopia, which has produced some of the earliest fossils attributable to the genus *Homo*. The Lee Adoyta area at Ledi-Geraru (~2.8 – 2.6 Ma) and the Maka'amitalu region at Hadar (~2.35 Ma) are particularly important, as these sites bookend the Plio-Pleistocene boundary and have yielded rich faunal assemblages useful for inferring paleoenvironments. Previous reconstructions, focused on faunal composition, ecomorphology, and stable isotopes, have suggested that Ledi-Geraru was more open and arid than the earlier Pliocene at Hadar. This study brings dental microwear texture analysis of fossil bovids from both areas to bear on reconstructions of their food preferences and, by extension, to suggest the availability of grass and woody cover. Texture analyses of extant bovids have shown that microwear parses species by percentage of grass versus browse items consumed. Previous studies of earlier Pliocene bovids from the lower Awash Valley show microwear textures clustering with extant mixed feeders that consume both grass and browse items. Here we report on microwear textures of bovid samples from Lee Adoyta ( $n=13$ ) and Maka'amitalu ( $n=6$ ) that preserve antemortem microwear. We first produced point clouds of microwear surfaces from high-resolution replicas of molar teeth using a white-light confocal profiler and then used scale-sensitive fractal analysis to characterize surface complexity and anisotropy, two attributes known to separate bovids by diet. Our results indicate that bovids from both areas evince high texture anisotropy and low complexity. These values fall within the range of living bovids with grass-dominated diets, suggesting that individuals from both Lee Adoyta and Maka'amitalu consumed mostly graminoids in the days or weeks prior to death. These fossil bovid samples do not differ significantly from one another but do contrast with those from earlier Pliocene Hadar sites, which fall within the extant browser-grazer intermediate range. While these results should be considered in light of sample size and faunal composition limitations, they are consistent with increased availability of grasses in the lower Awash Valley near the Plio-Pleistocene transition. This suggests that there was an expansion of grass-dominated environments with the appearance of early *Homo*, though causal links must await more research focused on this still sparsely sampled interval.

We thank the curators and staff of the National Museum of Ethiopia for access to the fauna from the Hadar and Ledi-Geraru research project areas. Funding for this study was supported by a LSB Leakey Foundation research grant.

Poster Presentation Number 158, Session 2, Friday 14:00 - 15:30

## Fraction woody cover from n-alkane distributions and their carbon isotopes: validation using modern soils and applications to the hominin fossil record

Kevin T. Uno<sup>1,2</sup>, Ruth R. Tweedy<sup>2</sup>

1 - Department of Human Evolutionary Biology, Harvard University · 2 - Department of Earth and Planetary Sciences, Harvard University

The idea that climate and environment played a significant role in shaping human evolution has roots in the theory of Natural Selection proposed by Darwin [1] and Wallace [2]. In 1925, Raymond Dart [3] wrote that the Taung child lived in “a vast open country with occasional wooded belts and a relative scarcity of water”. Although this assessment was based entirely on South Africa’s modern vegetation, Dart was adroit in drawing attention to the environmental context of *Australopithecus africanus*. In the century since the Taung Child was discovered and especially over the latter half of it, numerous methods for reconstructing the vegetation structure of hominin environments have been developed and applied at both paleontological and archeological sites. Cerling et al. [4] made a major advance by developing a quantitative proxy for vegetation that uses carbon isotopes to estimate fraction woody cover (FWC) through an empirically derived transform function. Here, we present a non-isotopic method for estimating FWC from plant wax distributions. We take advantage of the distinct molecular distributions of *n*-alkane homologs (C27 to C35) produced by woody dicots and grasses. Woody plants produce higher abundances of C27 and C29 whereas grasses produce higher abundances of C33 and C35. Since soils integrate organic matter from above ground biomass, their *n*-alkane distributions can be used to reconstruct landscape-scale vegetation cover. Using modern soil *n*-alkane molecular distributions from a wide range of African ecosystems, we develop a simple, linear transfer function for estimating FWC. We further corroborate these results with compound specific carbon isotope measurements of soil C31 *n*-alkanes, which serves as an independent method for reconstructing FWC [5]. The molecular distribution method can be used to reconstruct FWC at a wide range of paleontological and archeological sites across eastern Africa, potentially including Cenozoic paleontological sites that predate the spread of C4 grasses, using fossil soils (paleosols) and other alluvial sediments, including caves. We apply this new method to previously published data from Plio-Pleistocene paleontological or archeological sites as a proof of concept.

We thank the Government of Kenya, Kenya Wildlife Services, and the Wildlife Research and Training Institute for permission to conduct this research. We thank Thure Cerling for providing soil samples; Nicole deRoberts, Nikhil Chotirmall, Mark Batistich, Toby Zypman, Sungwon Jeong for lab assistance; and Pratigya Polissar and Peter deMenocal for insightful discussions. This research was supported by an NSF CAREER grant, the Vetlesen Foundation and a Climate Center Grant from the Lamont-Doherty Earth Observatory.

References: [1] Darwin, C., 1859. On the Origin of Species by Means of Natural Selection. Murray, London. [2] Wallace, A.R., 1858. On the tendency of varieties to depart indefinitely from the original type, Evolution in Victorian Britain. Routledge, pp. 369-379. [3] Dart, R.A., 1925. *Australopithecus africanus*: The Man-ape from South Africa. Nature 115, 5. [4] Cerling, T.E., Wynn, J.G., Andanje, S.A., Bird, M.I., Korir, D.K., Levin, N.E., Mace, W., Macharia, A.N., Quade, J., Remien, C.H., 2011. Woody cover and hominin environments in the past 6 million years. Nature. 476, 51-56. [5] Freeman, K., Pancost, R., 2013. Biomarkers for terrestrial plants and climate, Treatise on Geochemistry. Elsevier, pp. 395-416.

Podium Presentation, Session 3, Thursday 16:00 – 17:40=

## Semicircular canal morphology of Pliocene and Early Pleistocene hominins

Alessandro Urciuoli<sup>1,2,3,4</sup>, Clément Zanolli<sup>5</sup>, Ann Margvelashvili<sup>6,7,8</sup>, David Lordkipanidze<sup>6,7</sup>, Yameng Zhang<sup>9</sup>, Xiujie Wu<sup>10</sup>, Mercedes Conde-Valverde<sup>4,11</sup>, Bernhard Zipfel<sup>12</sup>, Friedemann Schrenk<sup>2,13</sup>, Ottmar Kullmer<sup>2,13</sup>

1 - Institute of Paleontology, University of Zurich, Zürich, Switzerland · 2 - Division of Palaeoanthropology, Senckenberg Research Institute and Natural History Museum Frankfurt, Frankfurt am Main, Germany · 3 - Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici ICTA-ICP, c/ Columnes s/n, Campus de la UAB, Cerdanyola del Vallès, Barcelona, Spain · 4 - Universidad de Alcalá, Cátedra de Otoacústica Evolutiva y Paleoantropología (HM Hospitales-UAH), Departamento de Ciencias de la Vida, Alcalá de Henares, Madrid, Spain · 5 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France · 6 - Georgian National Museum, Tbilisi, Georgia · 7 - The University of Georgia, Tbilisi, Georgia · 8 - Iv. Javakishvili Tbilisi State University, Tbilisi, Georgia · 9 - Joint International Research Laboratory of Environmental and Social Archaeology, Shandong University, Qingdao, China · 10 - Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China · 11 - Department of Anthropology, Binghamton University (SUNY), Binghamton, NY, USA · 12 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa · 13 - Department of Paleobiology and Environment, Institute of Ecology, Evolution, and Diversity, Goethe University, Frankfurt, Germany

The Plio-Pleistocene is marked by the diversification of hominins, with up to four distinct genera—*Australopithecus*, *Paranthropus*, *Kenyanthropus*, and *Homo*—and several recognized species. A mosaic of plesiomorphic and apomorphic morphological features in some specimens attributed to early *Homo* has led to an ongoing debate about the origin of our genus. Consequently, taxonomic and phylogenetic affinities of *Homo rudolfensis* and *Homo habilis* remain subjects of ongoing investigation. Similarly, the paleobiogeographic implications of early African *Homo erectus* (usually referred to as *Homo ergaster*) in relation to Asian *Homo erectus sensu stricto* continue to be controversial. These debates are frequently compounded by the fragmentary nature of the available cranial and postcranial evidence, which often provides limited definitive diagnostic information [1,2].

In this context, the morphology of the inner ear, especially that of the vestibular system, has emerged as a valuable analytical tool for phylogenetic, taxonomic, and population dynamics inference [3,4]. Comprising the semicircular canals (SCs) and vestibule, and housing the sensory organs for acceleration perception, this system is embedded within the petrous portion of the temporal bone and is often well-preserved in fossils. Prior investigations have established that SCs' dimensions and spatial organization can not only reflect locomotion, but they are also phylogenetically informative in hominins [5]. Hence, the examination of semicircular canal and vestibule morphology of Pliocene and Early Pleistocene hominins may offer a new opportunity to resolve the complex taxonomic questions surrounding the onset of the genus *Homo*.

After segmentation of inner ear structures based on micro computed tomography digital images, we used a diffeomorphic deformation analysis on the SCs and vestibule of Pliocene and Early Pleistocene hominins, including: *Paranthropus robustus* (n=9), *Paranthropus boisei* (n=2), *Kenyanthropus platyops* (n=1), *Australopithecus africanus* (n=15), *H. habilis* (n=2), *H. rudolfensis* (n=1), *H. ergaster* (n=4), *H. erectus* (n=6), and the South African early *Homo* SK 27. The SCs and vestibule of 12 modern humans were used as comparative material. We inspected shape data using principal component analysis and between-group component analysis (bgPCA), using genera (*Australopithecus*, *Paranthropus*, and *Homo*) as grouping factor. Typicality probabilities scores were computed for specimens of debated affinities.

Results show good separation among genera with both PCA and bgPCA (98% classification accuracy). *Paranthropus* species overlap with one another, whereas we observe two clusters within *Homo*, composed of *H. erectus* (except Lantian) + SK847 and by African *Homo species* + Lantian. The former cluster falls within the range of shape variation of modern humans (due to larger and rounder anterior and posterior SCs), while the latter is found between modern humans and *Paranthropus*. *K. platyops* shows closest affinities with *Paranthropus*, but it is classified as an outlier for all considered groups based on typicality probabilities, together with *H. habilis* and *H. rudolfensis* individuals. Notably, the *H. ergaster* specimen KNM-ER 3883 falls well within the *Paranthropus* cloud of points, possibly representing a pathological individual (extremely thick SCs).

The considerable SC shape variation of Pliocene/early Pleistocene hominins reflects the complex evolutionary history of the earliest representatives of our lineage. Although additional specimens should be investigated, our study reports the presence of two different SC morphotypes in early *Homo* species, which may help shedding light on the dispersal patterns within the initial out-of-Africa events for our genus.

MicroCT data: Ditsong Museum of Natural History, University of Witwatersrand, human-fossil-record.org, National Museums of Kenya, Werner Reimers Foundation, Max Plank Institute for Evolutionary Anthropology, Steinmann-Institute of Geology, Mineralogy und Palaeontology (Univ. Bonn), DST-NRF. Funds: R+D+I projects PID2020-116908GB-I00 and PID2021-122355NB-C31 (MCIN/AEI/10.13039/501100011033/FEDER, UE), CERCA Programme/Generalitat de Catalunya, European Union-NextGenerationEU, University of Bordeaux GPR "Human Past", Shota Rustaveli Georgian National Science Foundation (YS-21-1595). Computations: LOEWE Centre for Translational Biodiversity Genomics, Frankfurt am Main, Germany.

References: [1] Haile-Selassie, Y., Gibert, L., Melillo, S.M., Ryan, T.M., Alene, M., Deino, A., Levin, N.E., Scott, G., Saylor, B.Z., 2015. New species from Ethiopia further expands Middle Pliocene hominin diversity. *Nature*. 521, 483–488. [2] Antón, S.C., Middleton, E.R., 2023. Making meaning from fragmentary fossils: Early *Homo* in the Early to early Middle Pleistocene. *Journal of Human Evolution*. 179, 103307. [3] Urciuoli, A., Martínez, I., Quam, R., Arsuaga, J.L., Keeling, B.A., Díez-Valero, J., Conde-Valverde, M., 2025. Semicircular canals shed light on bottleneck events in the evolution

of the Neanderthal clade. *Nature Communications*. 16. [4] Urciuoli, A., Zanolli, C., Beaudet, A., Dumoncel, J., Santos, F., Moyà-Solà, S., Alba, D.M., 2020. The evolution of the vestibular apparatus in apes and humans. *eLife*. 9. [5] Spoor, F., Zonneveld, F., 1998. Comparative review of the human bony labyrinth. *American Journal of Physical Anthropology*. 107, 211–251.

Poster Presentation Number 159, Session 2, Friday 14:00 - 15:30

## ***SPRINGSCAPES*: investigating spring landscapes and human occupation in Palaeolithic Kazakhstan**

**Aristeidis Varis<sup>1</sup>**

1 - University of Oxford

The first dispersals of *Homo sapiens* into Asia occurred during the Late Pleistocene (ca. 129,000 – 11,700 years ago) and involved traversing arid regions. Springs are groundwater systems that likely played a vital role in human expansion across arid landscapes where surface waters, like rivers and lakes, are scarce [1]. Climate influences spring activity and the occupation potential of spring sites, as prolonged dry conditions may reduce the amount of water stored underground. On the other hand, tectonic processes can decouple springs from climate and provide a consistent source of freshwater in times of climate change and aridification [2]. A systematic study of tectonically active spring landscapes could use this theoretical background to investigate the relationship between spring formation and human occupation. Kazakhstan is a crucial area for studying Late Pleistocene spring landscapes, as it lies at the crossroads of human dispersals in arid Central Asia, has a high tectonic activity that promotes spring formation [3], and a growing number of Palaeolithic sites associated with springs [4]. *SPRINGSCAPES* is an upcoming Marie-Curie project that explores the possible use of spring sites as persistent places of human settlement in Paleolithic Kazakhstan. *SPRINGSCAPES* applies an interdisciplinary and multi-scalar approach to couple landscape evolution with site formation processes. Archaeological survey, spatial analysis, and geomorphological mapping target off-site questions of landscape change and archaeological visibility. In parallel, excavation, micromorphology, and geochemistry seek to investigate on-site human activity and the long-term evolution of spring sites. By focusing on the interplay between hunter-gatherer mobility and water availability, *SPRINGSCAPES* seeks to contribute to the study of prehistoric archaeology in Central Asia, propose geoarchaeological methods for the analysis of spring sites, and provide lessons for the use of groundwater resources in arid zones.

This research is facilitated by the Marie Skłodowska-Curie Actions

References: [1] Barboni, D., Ashley, G.M., Bourel, B., Arráiz, H., Mazur, J.-C., 2019. Springs, palm groves, and the record of early hominins in Africa. *Review of Palaeobotany and Palynology*. 266, 23–41. [2] Cuthbert, M.O., Gleeson, T., Reynolds, S.C., Bennett, M.R., Newton, A.C., McCormack, C.J., Ashley, G.M., 2017. Modelling the role of groundwater hydro-refugia in East African hominin evolution and dispersal. *Nature Communications*. 8. [3] Grützner, C., Campbell, G., Walker, R.T., Jackson, J., Mackenzie, D., Abdrakhmatov, K., Mukambayev, A., 2019. Shortening Accommodated by Thrust and Strike-Slip Faults in the Ili Basin, Northern Tien Shan. *Tectonics*. 38, 2255–2274. [4] Iovita, R., Varis, A., Namen, A., Cuthbertson, P., Taimagambetov, Z., Miller, C.E., 2020. In search of a Paleolithic Silk Road in Kazakhstan. *Quaternary International*. 559, 119–132.

Podium Presentation, Session 9, Saturday 14:00 – 15:20

### Behavioral complexity in *Homo floresiensis* reconsidered

E. Grace Veatch<sup>1</sup>, Nico Alamsyah<sup>2</sup>, Michael Pante<sup>3</sup>, Alex Pelissero<sup>4</sup>, Tewabe Negash<sup>5</sup>, Briana Pobiner<sup>6</sup>, Chelsea Betts<sup>7</sup>, Jatmiko<sup>8</sup>, Thomas Sutikna<sup>9</sup>, Matthew Tocheri<sup>10</sup>

1 - Human Origins Program, Department of Anthropology, National Museum of Natural History, Smithsonian Institution · 2 - Pusat Riset Arkeometri, Badan Riset dan Inovasi Nasional · 3 - Department of Anthropology & Geography, Colorado State University · 4 - Department of Anthropology & Geography, Colorado State University · 5 - Department of Anthropology & Geography, Colorado State University · 6 - Human Origins Program, Department of Anthropology, National Museum of Natural History, Smithsonian Institution · 7 - Department of Anthropology, University of Connecticut · 8 - Pusat Riset Arkeologi Prasejarah dan Sejarah, Badan Riset dan Inovasi Nasional · 9 - Pusat Riset Arkeometri, Badan Riset dan Inovasi Nasional · 10 - Department of Anthropology, Lakehead University

Liang Bua—an archaeological cave site on the Indonesian island of Flores—is well known as the type locality for *Homo floresiensis*. Initial studies and descriptions of the faunal remains from the site suggested that *H. floresiensis* hunted, butchered, and possibly cooked proboscideans (*Stegodon florensis insularis*) for food based on stegodont remains found in association with stone artifacts, burning identified on associated rodent bones, and the presence of cutmarks reported on three *Stegodon* bones. To test these early and influential interpretations of *H. floresiensis* behavior, we sampled 3,155 stegodont elements from Liang Bua for more detailed zooarchaeological and taphonomic analyses, including skeletal part profiles, breakage and fragmentation patterns, post-depositional processes, and bone surface modifications. Traces indicative of predation were molded and scanned using a 3D non-contact profilometer and compared to collections of marks with known origin. Our results indicate that both Komodo dragons (*Varanus komodoensis*) and *H. floresiensis* had access to and almost certainly consumed *Stegodon* at Liang Bua based on the presence of both varanid tooth scores and hominin tool marks, respectively, on stegodont elements. Stegodont age profiles indicate a dominance of subadult individuals and both adult and subadult elements exhibit high rates of post-depositional fragmentation. Nonetheless, skeletal-part profiles and frequencies of bone surface modifications suggest that the *Stegodon* assemblage at Liang Bua was the result of predation by Komodo dragons with scavenging by *H. floresiensis*. Moreover, only a single stegodont rib showed signs of exposure to fire but as it was recovered in sediments unconformably overlain by much younger deposits, the burning was likely not due to *H. floresiensis* behavior. These results challenge earlier claims regarding the behavioral complexity of *H. floresiensis* and suggest that this enigmatic hominin did not engage in a behavioral repertoire as diverse or as flexible as in *H. sapiens*, possibly due to an ancestry that does not include *H. erectus sensu lato*.

Fieldwork was authorized by Pusat Penelitian Arkeologi Nasional (Jakarta, Indonesia) and Pemerintah Daerah Kabupaten Manggarai (Flores, Nusa Tenggara Timur). Special thanks to Dr. Sofwan Noerwidi, Dr. I Made Geria, and the entire Liang Bua Team from Teras, Golo Manuk, Bere, and elsewhere around the world for their contributions to research at Liang Bua. Thank you to Dr. Joe Mendelson and staff from Zoo Atlanta for providing access to the facilities and research support.

Poster Presentation Number 160, Session 2, Friday 14:00 - 15:30

## Scars labelling in 3D lithic tools: a new approach under development

Alessio Veneziano<sup>1</sup>, Diego Lombao<sup>2,3</sup>, Vaquero Manuel<sup>4,5</sup>, Filippo Zangrossi<sup>4,5</sup>

1 - Muséum National d'Histoire Naturelle, CNRS-UMR 7209, Archéozoologie, Archéobotanique: Sociétés, Pratiques et Environnements, 75005 Paris, France · 2 - GEPN-AAT, Dpto. Historia, Facultade de Xeografía e Historia, Universidade Santiago de Compostela, Santiago de Compostela, Spain · 3 - Centro de Investigación Interuniversitario das Paisaxes Atlánticas Culturais (CISPAC) · 4 - Departament d'Història i Història de l'Art, Universitat Rovira i Virgili, Tarragona (URV), Spain · 5 - Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA), Tarragona, Spain

Stone tools offer a window onto the cultural behaviour and cognitive skills of their hominin makers. To unravel the manufacturing process of lithic tools, the identification and description of superficial features – namely scars and ridges – is of fundamental importance [1]. In this context, virtual methods can be of great assistance: from standardising measurements and expanding the morphological information retrievable from stone tools, to even developing techniques for the automatic refitting of flakes and cores. The main obstacle to a fertile adoption of virtual approaches in lithic studies is the lack of a reliable and fully automated method for identifying superficial features. The task is better exemplified by the name of “scars labelling”. In computational geometry, this labelling task goes under the methodological umbrella of “mesh segmentation”. Despite several approaches for the labelling of superficial features on virtual stone tools have been devised [2-5], no method can be currently considered fully automated.

Here we present a new approach to scars labelling in lithics based on the computation of discrete geometric features on 3D triangular meshes of stone tools. The protocol we developed relies on the combination of mesh flatness and saliency indices to estimate ridges, followed by the computation of vertex-to-ridge distance to retrieve an approximated template for each scar. Each template is then extended to label the whole scar by means of a region-growing algorithm.

The method is conceived to achieve full automation and it was developed in the open-source R programming environment. While not yet complete, our initial results are promising and provide insights into the challenges of feature identification in lithic tools. Further developments are needed to achieve higher labelling accuracy and to make the generalise the method. With this study, we hope to initiate a constructive debate and to obtain helpful feedback on novel directions for the development of the method presented.

References: [1] Inizan, M.L., Reduron-Ballinger, M., Roche, G., Tixier, J., 1999. *Préhistoire de la Pierre Taillée*. Vol. 4. Technologie de la Pierre Taillée. [2] Richardson, E., Grosman, L., Smilansky, U., Werman, M., 2014. Extracting scar and ridge features from 3D-scanned lithic artifacts. In: Earl, G., Sly, T., Wheatley, D., Romanowska, I., Papadopoulos, K., Murrieta-Flores, Chrysanthi, A., (Eds). *Archaeology in the Digital Era*, Amsterdam University Press, Amsterdam, p. 83–92. [3] Yang, X., Matsuyama, K., Konno, K., 2016. A new method of refitting mixture lithic materials by geometric matching of flake surfaces. *The Journal of the Society for Art and Science*. 15, 167-176. [4] Bullenkamp, J.P., Linsel, F., Mara, H., 2022. Lithic feature identification in 3D based on Discrete Morse Theory. In: Ponchio, F., Pintus, R. (Eds), *Eurographics Workshop on Graphics and Cultural Heritage*, The Eurographics Association, p. 55-58. [5] Pop, C.M., 2024. *Lithics3D*, (v0.52) [Computer Software]. <https://github.com/cornelmpop/Lithics3D/>

Poster Presentation Number 161, Session 2, Friday 14:00 - 15:30

## A 120 ka human femur from the Palaeolithic site of Caours (Somme Valley, France) showing a non-fully Neandertal condition

Amélie Vialet<sup>1</sup>, Jean-Luc Lochet<sup>2</sup>, Pierre Antoine<sup>3</sup>, Patrick Auguste<sup>4</sup>, Louise Magne<sup>5</sup>, Nicole Limondin-Lozouet<sup>3</sup>, Julie Dabkowski<sup>3</sup>, Guillaume Jamet<sup>3,6</sup>, David Hérissou<sup>7</sup>, Noémie Sévêque<sup>8</sup>, Jean-Jacques Bahain<sup>1</sup>, Caroline Tokarski<sup>9</sup>, Fabrice Bray<sup>10</sup>, Gwénaëlle Moreau<sup>11</sup>, Benoît Bertrand<sup>5</sup>

1 - Muséum national d'Histoire naturelle (MNHN), UMR 7194, UPVD, Paris, France · 2 - Institut National de Recherche archéologique préventive (INRAP) Nord-Picardie, Glisy, France · 3 - CNRS – Laboratoire de Géographie Physique : environnements quaternaires et actuels, UMR8591 Université Paris 1 Panthéon-Sorbonne, Université Paris Est-Créteil, Thiais, France · 4 - CNRS, Univ. Lille UMR 8198 – Evo-Eco-Paléo, Lille, France, · 5 - Univ. Lille, CHU Lille, ULR 7367 - U'TML&A - Unité de Taphonomie Médico-Légale & d'Anatomie, Lille, France · 6 - Inrap Grand Ouest, Laboratoire de Géographie Physique, Environnements Quaternaires et actuels, Meudon Cedex, France · 7 - UMR7041 ArScAn, équipe AnTET, MSH Mondes, Nanterre Cedex, France · 8 - Géoarchéon, Vigneulles-lès-Hattonchâtel, France · 9 - Institut de Chimie et Biologie des Membranes & Nano-objets, UMR CNRS 5248, Université de Bordeaux, Bordeaux, France · 10 - Miniaturisation pour la Synthèse, l'Analyse & la Protéomique (MSAP), USR CNRS 3290, Université de Lille 1 Sciences et Technologies, Villeneuve d'Ascq Cedex, France · 11 - SpaceArc, Ballan-Miré, France

The Caours Eemian tufa sequence and associated palaeolithic site is located on the lowest terrace of the Scardon, a minor tributary of the Somme River in northern France. In 2016, a human femur (CN1-1) was discovered in the archaeological layer (N-1) contemporary with the Eemian climatic optimum based on the results of an interdisciplinary research program spanning more than two decades [2]. The thick tufa formation (3.5 to 4 m) is preserved over an area of about 30,000 m<sup>2</sup>. Since 2005, a total of fifteen archaeological excavation campaigns have been conducted on the site. In the southern part of the excavation (Sector 2/S-2), corresponding to the reference area, four well-preserved archaeological levels have been identified (N-1 to N-4).

Dating results, obtained by U-series on carbonates, OSL on fluvial sediments, TL on heated flints, and ESR/U-series on tooth enamel provide a robust chronological frame for the Caours sequence and the N1 level bearing the human remain, with a weighted mean age of 123.1 ± 2.8 ka. Most mammalian faunal remains come from archaeological level N-1 (NISP=8,861). The species are: *Palaeoloxodon antiquus*, *Stephanorhinus hemitoechus*, *Equus taubachensis*, *Bos primigenius*, *Cervus elaphus*, *Dama dama*, *Capreolus capreolus*, *Sus scrofa*, *Castor fiber*, *Aonyx antiqua*, *Canis lupus*, *Ursus arctos*. This mammal assemblage is typical of forest environments that developed during the last interglacial. The taphonomical study of the fauna confirmed that humans were the only accumulators of the bones. The archaeological level N-1 corresponds to the last phase of occupation of the site. The area under investigation spanned 499 m<sup>2</sup>. The use of fire by humans is attested in this area. Caours level N-1 yielded 1,348 lithic artifacts. The lithic production system is characterised by a discoidal debitage. A few Levallois flakes appear to have been brought to the site.

The CN1-1 human remain is a diaphysis of a right femur preserved over approximately two-thirds of its length. Due to its small dimensions (175 mm), it is attributed to a young individual as confirmed by the weak thickness of the cortical part of the bone in comparison with values measured on adults (fossil hominins and *Homo sapiens*). For comparisons, we considered immature fossil hominins whose estimated age-at-death ranges from 5 to 12 years (Arago 38, Marillac 25, Cova Negra 1 and Teshik-Tash) as well as a series of *Homo sapiens* (n=12) from the New Mexico Decedent Image Database (NMDID). In addition, the study incorporated two adult specimens from the same temporal range period of CN1-1 (i.e. around 120 ky, from Hohlenstein-Stadel and La Chaise - abri Bourgeois Delaunay). Other European Middle and Upper Pleistocene fossils were added using published data including measurements of adolescent and adult femora from Sima de los Huesos and the femur from Venosa-Notarchirico. Linear measurements were obtained at standardized heights of the diaphysis with the 80% measured at the estimated subtrochanteric level on CN1-1 and the 50% taken just above the breakage of the midshaft. Furthermore, the cortical area (CA) and total cross-section area (TA) were also measured and used to calculate the CA/TA ratio. The cortical thickness of the femur was obtained by semi-automatic segmentation and a cortical thickness map was produced using Dragonfly software, version 2022.2 for Windows.

Results show that the CN1-1 femur differs from Neandertals, particularly in the flattening of the bone at mid-diaphysis and in the pattern of bone distribution. The bone is thickest on the lateral edge, which is reinforced by the presence of a developed gluteal complex. Because of these traits, the CN1-1 is close to early Middle Pleistocene fossils such as those from the Arago cave (France) and Venosa-Notarchirico (Italy). It demonstrates that morphological diversity persisted at the beginning of the Upper Pleistocene, even as Neandertal-specific traits become dominant.

Poster Presentation Number 162, Session 2, Friday 14:00 - 15:30

## Expansion of dietary niche during the Plio-Pleistocene in Sterkfontein *Australopithecus* based on stable isotope analysis

Marissa Vink<sup>1</sup>, Jennifer Leichliter<sup>1,2</sup>, Hubert Vonhof<sup>3</sup>, Recognise Sambo<sup>4</sup>, Dominic Stratford<sup>4,5</sup>, Marion Bamford<sup>2</sup>, Alfredo Martinez-Garcia<sup>3</sup>, Tina Lüdecke<sup>1,2</sup>

1 - Emmy Noether Group for Hominin Meat Consumption, Max Planck Institute for Chemistry, Mainz, Germany · 2 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa · 3 - Department for Climate Geochemistry, Max Planck Institute for Chemistry, Mainz, Germany · 4 - School of Geography, Archaeology and Environmental Studies, University of the Witwatersrand, Johannesburg, South Africa · 5 - Department of Anthropology, Stony Brook University, Stony Brook, New York, USA

Stable isotope data from diagenetically robust tooth enamel can be used to reconstruct the dietary niches of animals in paleo-contexts. The two main photosynthetic pathways in plants ( $C_3$  and  $C_4$ ) have different isotopic fractionations, resulting in a separation between their stable carbon isotope values. In African ecosystems, stable carbon isotopes ( $\delta^{13}C_{\text{enamel}}$ ) in herbivores distinguish browsers ( $C_3$ -feeders), grazers ( $C_4$ -feeders) and mixed-feeders.  $\delta^{13}C_{\text{enamel}}$  in carnivores reflects the preferred type of prey (i.e., browsers, grazers, or mixed-feeders). Nitrogen isotopes ( $\delta^{15}N_{\text{enamel}}$ ) are linked to an organism's trophic level within its local food-web. An enrichment in  $\delta^{15}N$  values between consumer tissues and diet is observed because of the isotopic fractionation occurring during metabolism. This process results in a 3 to 6‰ increase in carnivore  $\delta^{15}N$  values compared to that of the prey they consume. Thus, the combination of  $\delta^{13}C_{\text{enamel}}$  and  $\delta^{15}N_{\text{enamel}}$  values can be used to reconstruct food web structures and the trophic position of an organism in both modern and paleo contexts [1-2].

The Sterkfontein Caves, located in the Cradle of Humankind, South Africa, is a fossil-bearing cave site containing numerous infills that have yielded rich Plio-Pleistocene fossil assemblages, including three hominin genera of which *Australopithecus* is particularly abundant. Seven previously analyzed *Australopithecus* sp. specimens from Member 4, Sterkfontein (ca. 3.4 Ma), revealed a large variation in their  $\delta^{15}N_{\text{enamel}}$  values compared to the other contemporaneous mammalian groups (i.e., herbivores, carnivores, and non-hominin primates; [3]). Furthermore, this group of hominins was consistently lower in  $\delta^{15}N_{\text{enamel}}$  than coexisting carnivores, suggesting they were consuming a variable, but plant-based diet. Additionally,  $\delta^{13}C_{\text{enamel}}$  values from the same enamel samples shows this diet consisting predominantly of  $C_3$  plants.

The Jacovec Cavern of the Sterkfontein system is slightly older than Member 4 (ca.  $3.61 \pm 0.09$  Ma) and has also yielded *Australopithecus* fossils as well as a diverse assemblage of faunal remains. We measured  $\delta^{13}C_{\text{enamel}}$  and  $\delta^{15}N_{\text{enamel}}$  values of a single aliquot of tooth enamel (~5 mg) of herbivores, carnivores, non-hominin primates, and australopiths, from the hominin-bearing deposits in this chamber to expand our understanding of the evolution of the dietary niche of some of the oldest hominins in South Africa.

$\delta^{13}C_{\text{enamel}}$  values show the expected separation between browsing, grazing, and mixed-feeding herbivores. Carnivores display  $\delta^{15}N_{\text{enamel}}$  values that are, on average, 3.6‰ higher than those of coexisting herbivores, consistent with the expected trophic enrichment of 3–6‰. These results provide an isotopic baseline for interpreting  $\delta^{13}C_{\text{enamel}}$  and  $\delta^{15}N_{\text{enamel}}$  values of the contemporary non-hominin and hominin primate samples, which can help assess ecological interactions and potential competition between fauna and coexisting early hominins.

The six analyzed Jacovec australopith individuals are lower in their  $\delta^{15}N_{\text{enamel}}$  values than the carnivores, indicating a primarily plant-based diet. Their  $\delta^{13}C_{\text{enamel}}$  values correspond with mixed  $C_3/C_4$  sources, but with a greater contribution of  $C_3$  plants (~60%). When comparing the Jacovec results to the previously published results of Sterkfontein Member 4 australopiths, the Jacovec hominins occupy a smaller dietary niche ( $4.3\text{‰}^2$  vs.  $9.9\text{‰}^2$ , respectively), with less variable  $\delta^{15}N_{\text{enamel}}$  values, but slightly more variable  $\delta^{13}C_{\text{enamel}}$  values. This suggests a shift toward greater dietary flexibility over time, which reflects the ecological adaptability - and ultimately the evolutionary success - of *Australopithecus*, which existed in Africa for over 2 Ma across different savanna biomes.

References: [1] Leichliter, J., Lüdecke, T., Foreman, A., Bourgon, N., Duprey, N., Vonhof, H., Soukavaty, V., Bacon, A.-M., Sigman, D., Tütken, T., Martínez-García, A., 2023. Tooth enamel nitrogen isotope composition records trophic position: a tool for reconstructing food webs. *Communications biology* 6, 373. [2] Lüdecke, T., Leichliter, J.N., Aldcias, V., Bamford, M.K., Biro, D., Braun, D.R., Capelli, C., Cybulski, J.D., Duprey, N.N., Ferreira da Silva, M.J., Foreman, A.D., Habermann, J.M., Haug, G.H., Martínez, F.I., Mathe, J., Mulch, A., Sigman, D.M., Vonhof, H., Bobe, R., Carvalho, S., Martínez-García, A., 2022. Carbon, nitrogen, and oxygen stable isotopes in modern tooth enamel: A case study from Gorongosa National Park, central Mozambique. *Frontiers in Ecology and Evolution* 10, 10:958032. [3] Lüdecke, T., Leichliter, J.N., Stratford, D., Sigman, D.M., Vonhof, H., Haug, G.H., Bamford, M.K., Martínez-García, A., 2025. *Australopithecus* at Sterkfontein did not consume substantial mammalian meat. *Science* 387, 309-314.

Poster Presentation Number 163, Session 2, Friday 14:00 - 15:30

## Rethinking subsistence during Neanderthal–human coexistence through ZooMS and zooarchaeology

Anna Wagner<sup>1</sup>, Frankie Tait<sup>1</sup>, Britt M. Starkovich<sup>2,3</sup>, Geoff M. Smith<sup>1</sup>, Karen Ruebens<sup>1</sup>

1 - Department of Archaeology, University of Reading, UK · 2 - Senckenberg Centre for Human Evolution and Palaeoenvironment at the University of Tübingen, Germany · 3 - Institute for Archaeological Sciences, University of Tübingen, Germany

Recent studies have confirmed that Neanderthals and *Homo sapiens* coexisted in parts of Europe between approximately 48,000 and 40,000 years ago [1,2]. Zooarchaeological and biomolecular studies have shown that Neanderthals were skilled hunters, primarily exploiting medium to large herbivores such as cervids, equids, and bovids. In contrast, early Upper Palaeolithic humans exhibited greater dietary flexibility, supplementing similar large game with smaller animals (e.g. birds, rabbits, fish) and occasionally carnivores, which were also used for raw materials and ornaments [3-5]. However, little is known about how these patterns emerged during the actual period of Neanderthal–*Homo sapiens* coexistence. As part of the COEXIST project, we conducted a comprehensive literature review of faunal assemblages from Central and Southeast Europe dated between 55,000 and 40,000 years ago. Preliminary results reveal some regional variability, but interpretations are hindered by a scarcity of subsistence data due to a lack of focus on bone material during excavations, language barriers, and inconsistent reporting standards.

To address these gaps, we have integrated traditional zooarchaeological analysis with Zooarchaeology by Mass Spectrometry (ZooMS) to analyse fragmented bone assemblages from cave sites across Germany, Slovakia, Romania, Serbia, and Montenegro. Initial ZooMS success rates exceed 90%, allowing us to expand taxonomic identification beyond what is morphologically possible. Combined with taphonomic data, these results both confirm and refine existing interpretations of subsistence strategies and reveal broader taxonomic exploitation. When combined with available zooarchaeological data from the region this will allow us to compare subsistence practices between Neanderthals and *Homo sapiens* across the studied region.

This ongoing project aims to analyse additional assemblages using this integrated approach, enhancing our understanding of regional variation in subsistence practices and illuminating behavioural differences between coexisting Neanderthals and *Homo sapiens* in Central and Southeast Europe.

References: [1] Hublin, J.-J., Sirakov, N., Aldeias, V., Bailey, S., Bard, E., Delvigne, V., Endarova, E., Fagault, Y., Fewlass, H., Hajdinjak, M., Kromer, B., Krumov, I., Marreiros, J., Martisius, N.L., Paskulin, L., Sinet-Mathiot, V., Meyer, M., Pääbo, S., Popov, V., Rezek, Z., Sirakova, S., Skinner, M.M., Smith, G.M., Spasov, R., Talamo, S., Tuna, T., Wacker, L., Welker, F., Wilcke, A., Zahariev, N., McPherron, S.P., Tsanova, T., 2020. Initial Upper Palaeolithic *Homo sapiens* from Bacho Kiro Cave, Bulgaria. *Nature*. 581, 299–302. [2] Mylopotamitaki, D., Weiss, M., Fewlass, H., Zavala, E.I., Rougier, H., Sümer, A.P., Hajdinjak, M., Smith, G.M., Ruebens, K., Sinet-Mathiot, V., Pederzani, S., Essel, E., Harking, F.S., Xia, H., Hansen, J., Kirchner, A., Lauer, T., Stahlschmidt, M., Hein, M., Talamo, S., Wacker, L., Meller, H., Dietl, H., Orschiedt, J., Olsen, J.V., Zeberg, H., Prüfer, K., Krause, J., Meyer, M., Welker, F., McPherron, S.P., Schuler, T., Hublin, J.-J., 2024. *Homo sapiens* reached the higher latitudes of Europe by 45,000 years ago. *Nature*. 626, 341–346. [3] Smith, G.M., Ruebens, K., Zavala, E.I., Sinet-Mathiot, V., Fewlass, H., Pederzani, S., Jaouen, K., Mylopotamitaki, D., Britton, K., Rougier, H., Stahlschmidt, M., Meyer, M., Meller, H., Dietl, H., Orschiedt, J., Krause, J., Schuler, T., McPherron, S.P., Weiss, M., Hublin, J.-J., Welker, F., 2024. The ecology, subsistence and diet of ~45,000-year-old *Homo sapiens* at Ilshöhle in Ranis, Germany. *Nature Ecology & Evolution*. 8, 564–577. [4] Smith, G.M., Spasov, R., Martisius, N.L., Sinet-Mathiot, V., Aldeias, V., Rezek, Z., Ruebens, K., Pederzani, S., McPherron, S.P., Sirakova, S., Sirakov, N., Tsanova, T., Hublin, J.-J., 2021. Subsistence behavior during the Initial Upper Paleolithic in Europe: Site use, dietary practice, and carnivore exploitation at Bacho Kiro Cave (Bulgaria). *Journal of Human Evolution*. 161, 103074. [5] Starkovich, B.M., 2012. Intensification of small game resources at Klissoura Cave 1 (Peloponnese, Greece) from the Middle Paleolithic to Mesolithic. *Quaternary International*. 264, 17–31.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## Exploring the evolutionary pathways of the Catarrhine dental diversity with possibilistic models

Axelle Elise Colette Walker<sup>1</sup>, Cedric Gaucherel<sup>2</sup>, Vincent Lazzari<sup>1</sup>, Corentin Gibert<sup>3,4</sup>, Franck Guy<sup>1</sup>

1 - PALEVOPRIM, UMR 7262 CNRS and University of Poitiers, France · 2 - AMAP, INRAE, University of Montpellier, CNRS, IRD, Cirad, France · 3 - SEPL, Georgia Institute of Technology, Atlanta, USA · 4 - Evo-Eco-Paleo, UMR 8198, University of Lille, France

Characterizing the evolution of dental morphology in catarrhine primates is essential for interpreting their adaptive responses to environmental shifts, particularly those related to dietary constraints. This study presents an innovative approach based on qualitative and possibilistic modelling, using the Ecological Dynamics Events Networks (EDEN) framework [1] to explore evolutionary pathways of dental morphology.

We developed two discrete-event models from morphological data comprising four dental variables measured in both extant and fossil catarrhine primates. The first model, MorphoMod, simulates the full range of possible dental diversity configurations from a hypothetical common ancestor. The second model, AbraMod, specifically tests the hypothesis that increased enamel thickness evolved as an adaptation to abrasive diets [2–4], often associated with arid environments. Together, these models reconstruct possible morphological transitions between ancestral forms and modern or fossil taxa. They highlight key dental traits, such as cusp shape, enamel thickness, and the complexity of the occlusal surface through crenulations or lophs, as major responses of evolutionary pathways under ecological constraints. Moreover, the models also predict morphologies that are currently undocumented in the fossil record, raising questions about their potentially transient nature, the biases inherent to the fossilization process, or the developmental constraints that may have limited the emergence or long-term viability of certain trait combinations.

This possibilistic framework provides flexible tool for investigating the relationships between form, function, and ecology in a macroevolutionary context. It facilitates the exploration of dental trait combinations that may not yet be documented, while assessing their evolutionary plausibility under varying ecological conditions. This approach opens new avenues for understanding dietary adaptations in primate lineages, particularly in the context of hominin evolution. The future integration of these models with detailed paleoenvironmental data and chronological information from fossil sites will help refine the proposed evolutionary scenarios and shed light on the real dynamics of past morphological diversification.

This research was supported by the Région Nouvelle-Aquitaine (Project INDENT 2020-2023), the French National Research Agency (ANR DieT-PrimE [ANR-17-CE02-0010-01, PI V. Lazzari]), the French Ministry of Education, Higher Education and Research, and the Centre National de la Recherche Scientifique (CNRS). We extend our gratitude to J.-R. Boissarie and the OGRE Mission for providing access to fossil specimens from the Shungura Formation in Ethiopia, and to G. Merceron for his contribution of molds and specimens from Shungura and Greece. We also warmly thank F. Spoor, L. Gonzales, and B. Benefit for granting access to *Victoriapithecus* material. Special thanks to D. Guatelli-Steinberg, E. Schulz-Kornas and L. Martinez-Martinez for their valuable comments on this study. We also thank G. Thierry for his discussions during the launch of the project. We are grateful to E. Gilissen from the Royal Museum of Central Africa (RCMA), Tervuren, Belgium, and J. Cuisin from the Muséum National d'Histoire Naturelle (MNHN), Paris, France, for granting access to critical specimens used in our work. We also acknowledge A. Mazurier (IC2MP), X. Valentin, A. Euriat, J. Surault, A. Thiebaut, L. Scribano, R. Henry and E. Sabourin (PALEVOPRIM) for their technical support and assistance with 3D data acquisition. The 3D dental scans were obtained at the PLATINA platform of the University of Poitiers. We thank here the long-standing efforts of F. Pommereau for providing the powerful and user-friendly EDEN platform.

References: [1] Gaucherel, C., Pommereau, F., 2019. Using discrete systems to exhaustively characterize the dynamics of an integrated ecosystem. *Methods in Ecology and Evolution*. 10, 1615–1627. [2] King, S.J., Arrigo-Nelson, S.J., Pochron, S.T., Semperebon, G.M., Godfrey, L.R., Wright, P.C., Jernvall, J., 2005. Dental senescence in a long-lived primate links infant survival to rainfall. *Proceedings of the National Academy of Sciences*. 102, 16579–16583. [3] Rabenold, D., Pearson, O.M., 2011. Abrasive, Silica Phytoliths and the Evolution of Thick Molar Enamel in Primates, with Implications for the Diet of *Paranthropus boisei*. *PLoS ONE*. 6, e28379. [4] Pampush, J.D., Duque, A.C., Burrows, B.R., Daegling, D.J., Kenney, W.F., McGraw, W.S., 2013. Homoplasy and thick enamel in primates. *Journal of Human Evolution*. 64, 216–224.

Virtual Pecha Kucha Presentation, Session 8, Saturday 11:00 – 12:30

## Is there a reproducibility crisis in lithic analysis?

**Manuel Will<sup>1,2</sup>, Justin Pargeter<sup>2,3</sup>, Alison Brooks<sup>4</sup>, Katja Douze<sup>5</sup>, Metin Eren<sup>6</sup>, Huw S. Groucutt<sup>7</sup>, Jessica McNeil<sup>8</sup>, Alex Mackay<sup>9</sup>, Kathryn Ranhorn<sup>10</sup>, Eleanor Scerri<sup>11</sup>, Matthew Shaw<sup>9</sup>, Christian Tryon<sup>12</sup>, Alice Leplongeon<sup>13</sup>**

1 - Department of Early Prehistory and Quaternary Ecology, University of Tübingen, Tübingen, Germany, · 2 - Palaeo-Research Institute, University of Johannesburg, Johannesburg, South Africa · 3 - Department of Anthropology, New York University, NY, USA · 4 - Center for the Advanced Study of Human Paleobiology, Department of Anthropology, George Washington University, Washington, DC, USA · 5 - Laboratory Archaeology and Population in Africa, Section of Biology, Faculty of Science, University of Geneva, Geneva, Switzerland · 6 - Department of Anthropology, Kent State University, Kent, OH, USA · 7 - Department of Classics and Archaeology, University of Malta, Msida, Malta · 8 - Department of Anthropology, Harvard University, Cambridge, MA, USA · 9 - Center for Archaeological Science, University of Wollongong, Wollongong, Australia · 10 - School of Human Evolution and Social Change, Arizona State University, Tempe, AZ, USA · 11 - Pan-African Evolution Research Group, Max Planck Institute of Geoanthropology, Jena, Germany · 12 - Department of Anthropology, University of Connecticut, Storrs, CT, USA · 13 - Research Unit Histoire naturelle de l'Homme préhistorique (HNHP) 7194, CNRS, Université de Perpignan Via Domitia, Muséum national d'Histoire naturelle, Paris, France

Stone tools constitute the principal source to study the material culture and behavioral adaptations of Pleistocene hominins. Despite their importance, lithic artifacts can be problematic to study because analysts differ widely in their methods, theoretical approaches, and the data they collect. The extent to which differences in lithic data relate to prehistoric behavioral variability or differences between archaeologists studying them today remains incompletely known. Does lithic analysis have a reproducibility crisis, and if so, what causes it, and how can we improve matters? These are crucial questions for Paleolithic archaeology – as for any scientific field – since comparisons among assemblages and sites are a key component of everyday research that allows us to answer larger-scale questions on behavioral adaptations, cultural transmission, or dispersals. Such issues become all the more pressing in the age of big data and machine learning as basis in the context of large-scale meta-analyses.

In 2018, we founded the “Comparative analysis of Middle Stone Age artifacts in Africa” (CoMSAfrica) network at a workshop in 2018 to tackle these and other questions by gathering a collaborative group of 12 international scholars working in different parts of Africa with diverse methodological backgrounds in lithic analysis and access to large MSA datasets [1]. As a first step, the CoMSAfrica network aimed to address the issue of comparative research with the most extensive lithic replicability study yet, involving 11 analysts, 100 unmodified experimental flakes, and 38 ratio, discrete, and nominal attributes that are frequently recorded by Palaeolithic archaeologists around the world [2]. We use mixture models to show strong inter-analyst replicability scores on several attributes – with many measurements but also several discrete traits – making them well suited to comparative lithic analyses. At the same time, many complex attributes routinely recorded were not found to be replicable, such as the orientation of dorsal scars. We discuss some of the reasons why attributes fail to replicate and how better agreement may be achieved in the future such as by decreasing the number of categories for discrete traits, increased training in quantitative methods or the use of video instructions to take specific measurements. Based on our results, we highlight 17 attributes that we consider reliable for compiling datasets collected by different individuals for comparative studies in the Paleolithic. Demonstrating this basic level of replicability is a crucial first step in tackling more general problems of data comparability in lithic analysis and our ability to conduct large-scale meta-analyses.

References: [1] Will, M., Tryon, C., Shaw, M., Scerri, E.M.L., Ranhorn, K., Pargeter, J., McNeil, J., Mackay, A., Leplongeon, A., Groucutt, H.S., Douze, K., Brooks, A.S., 2019. Comparative analysis of Middle Stone Age artifacts in Africa (CoMSAfrica). *Evolutionary Anthropology: Issues, News, and Reviews*. 28, 57–59. [2] Pargeter, J., Brooks, A., Douze, K., Eren, M., Groucutt, H.S., McNeil, J., Mackay, A., Ranhorn, K., Scerri, E., Shaw, M., Tryon, C., Will, M., Leplongeon, A., 2023. Replicability in lithic analysis. *American Antiquity*. 88, 163–186.

Pecha Kucha Presentation, Session 5, Friday 11:00 – 12:30

## Primate locomotor diversity and the evolution of hominin bipedalism

Ashleigh L Wiseman<sup>1,2</sup>, Oliver E. Demuth<sup>3,4</sup>, Jeremy DeSilva<sup>5</sup>, Tara Chapman<sup>6,7</sup>, Robin H Crompton<sup>8</sup>, Marta Mirazón Lahr<sup>3,9</sup>, Kujani Wanniarachchi<sup>10</sup>, Evie Vereecke<sup>11</sup>

1 - Department of Anthropology, University College London, London, UK · 2 - McDonald Institute for Archaeological Research, University of Cambridge, Cambridge, UK · 3 - Clare College, University of Cambridge, Cambridge, UK · 4 - Department of Earth Sciences, University of Cambridge, Cambridge, UK · 5 - Department of Anthropology, Dartmouth College, USA · 6 - Operational Direction Earth and History of Life, Royal Belgian Institute of Natural Sciences, Brussels (RBINS), Belgium · 7 - Laboratory of Anatomy, Biomechanics and Organogenesis (LABO), Faculty of Medicine, Université Libre de Bruxelles (ULB), Brussels, Belgium · 8 - Departments of Ageing and Chronic Disease and Archaeology, Classics and Egyptology, University of Liverpool, Liverpool · 9 - Department of Archaeology, University of Cambridge, Cambridge · 10 - Trinity Hall, University of Cambridge, Cambridge, UK · 11 - Department of Development and Regeneration, KU Leuven Campus Kulak, Kortrijk, Belgium

Locomotor transitions, particularly the shift from arboreal locomotion to terrestrial bipedalism, have been central to our evolutionary history. These transitions have shaped not only morphological diversity but also the biomechanical capacities of extant and extinct individuals. Yet, the functional mechanisms underpinning these shifts—especially the role of muscle leverage in the lower limb—remain poorly resolved. Understanding how biomechanical traits relate to locomotor behaviour is essential for interpreting the adaptive significance of postcranial morphology in the fossil record.

Here, we reconstruct and compare lower limb musculoskeletal models for 13 primate taxa, including five fossil hominins. Our sample comprises eight subject-specific models based on CT-scanned and dissected specimens (chimpanzee, gorilla, orangutan, bonobo, macaque, gibbon, siamang and modern human), and five fossil hominin models (*Australopithecus prometheus*, *Au. afarensis*, *Au. sediba*, *Homo ergaster* and *H. neanderthalensis*) that were digitally reconstructed and corrected for damage. These taxa span a broad range of locomotor ecologies, from suspensory and knuckle-walking apes to an obligate terrestrial biped [1]. Using 3D musculoskeletal models of the lower limbs of these 13 primate taxa (e.g., [2]), we calculated moment arms for muscles that cross the hip, knee, ankle and metatarsophalangeal joints. These resulting moment arm curves provide an estimate of muscle leverage, enabling comparisons of functional potential across taxa.

Our results reveal distinct biomechanical clustering among locomotor groups. Terrestrial bipeds—such as modern *H. sapiens* and *H. ergaster*—are characterised by greater hip extensor and adductor leverage, especially during postures associated with upright stance and mid-stance propulsion. In contrast, more forelimb-supported taxa (e.g., *Pan*, *Gorilla* and *Pongo*) show lower leverage for these same muscle groups, consistent with their quadrupedal and climbing repertoires. Phylogenetic comparative analyses, incorporating both evolutionary history and quantitative musculoskeletal data [3], identify hip extension and adduction as the most influential axes of variation in distinguishing locomotor modes. By accounting for shared ancestry and evolutionary history, it shows that changes in these muscle groups were key to locomotor function and the shift from arboreal movement to terrestrial bipedalism in the hominin lineage.

Within this biomechanical space, the australopiths exhibit mosaic traits. *Au. prometheus* has relatively low leverage in the distal lower limb, particularly those in the knee and ankle, resembling more arboreal taxa and suggesting continued reliance on forelimb-assisted movement. In contrast, later *Homo* species cluster with modern humans, showing mechanical specialisations for obligate bipedalism. These patterns support the hypothesis that early hominins retained arboreal capabilities while gradually acquiring the derived traits associated with efficient terrestrial bipedal locomotion.

The phylogenetic comparative methods further suggest that the last common ancestor of African apes and hominins was primarily arboreal. Rather than descending from a terrestrial knuckle-walker, as some early theories have proposed [4], our findings are consistent with a model of convergent evolution in which terrestrial adaptations arose independently in at least three lineages: *Pan*, *Gorilla* and hominins. This has significant implications for interpreting the locomotion of the last common ancestor, and for reconstructing the selective pressures that shaped early hominin evolution.

Overall, this study provides new biomechanical evidence for the evolutionary trajectory of bipedalism in hominins. By integrating musculoskeletal modelling with phylogenetic methods, we offer a quantitative framework to test locomotor adaptation in extant and extinct primates.

This research was supported by a Leverhulme Trust Early Career Fellowship (grant no. ECF-2021-054), the Isaac Newton Trust (Project\_21.08(a)) at the University of Cambridge and the AABA Cobb Professional Development Grant. Data collection at the National Museums of Kenya was supported by the Ng'ipalajem Project (ERC, Grant No. 101020478).

References: [1] Granatosky, M.C., 2018. A Review of locomotor diversity in mammals with analyses exploring the influence of substrate use, body mass and intermembral index in primates. *Journal of Zoology*. 306, 207-216. [2] Wiseman, A.L.A., Charles, J.P., Hutchinson, J.R., 2024. Static versus dynamic muscle modelling in extinct species: a biomechanical case study of the *Australopithecus afarensis* pelvis and lower extremity. *PeerJ*. 12, e16821. [3] Adams, D.C., Collyer, M.L., 2018. Multivariate Phylogenetic Comparative Methods: Evaluations, Comparisons, and Recommendations. *Systematic Biology*. 67(1), 14-31. [4] Crompton, R.H., Sellers, W., Davids, K., McClymont, J., 2023. Biomechanics and the origins of human bipedal walking: The last 50 years. *Journal of Biomechanics*. 157, 111701.

Poster Presentation Number 164, Session 2, Friday 14:00 - 15:30

## Metatarso- and metacarpophalangeal joint biomechanics of *Pongo pygmaeus* and *Pongo abelii*

Joseph K. Won<sup>1,2,3</sup>, Shelby Pirtle<sup>1,2,3</sup>, Caley M. Orr<sup>4,5</sup>, Matthew W. Tocheri<sup>6,7,8</sup>, Biren A. Patel<sup>9,10</sup>

1 - PhD Program in Anthropology, Graduate Center of the City University of New York, NY, USA · 2 - New York Consortium in Evolutionary Primatology, NY, USA · 3 - Department of Anthropology, Hunter College of the City University of New York, NY, USA · 4 - Department of Cell and Developmental Biology, University of Colorado School of Medicine, CU, USA · 5 - Department of Anthropology, University of Colorado Denver, CO, USA · 6 - Department of Anthropology, Lakehead University, Thunder Bay, Canada · 7 - Human Origins Program, Smithsonian Institution, Washington DC, USA · 8 - Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage, Wollongong University, New South Wales, Australia · 9 - Division of Integrative Anatomical Sciences, Department of Medical Education, Keck School of Medicine, University of Southern California, CA, USA · 10 - Human and Evolutionary Biology Section, Department of Biological Sciences, University of Southern California, CA, USA

Dorsal canting (DC) refers to the angular orientation of the proximal articular surface of proximal phalanges and is frequently used to infer locomotor behavior in the hominin fossil record. In the foot, humans exhibit the greatest degree of pedal DC (consistently  $>90^\circ$ ), reflecting the functional importance of dorsiflexion at the metatarsophalangeal (MTP) joint near the end of stance phase of terrestrial bipedal locomotion [1,2]. In contrast, orangutans display the lowest degree of pedal DC (consistently  $<90^\circ$ ; i.e., plantarly canted), corresponding with the demands of plantarflexion during arboreal below-branch suspension. A comparable angular measure in the hand also reflects functional variation at the metacarpophalangeal (MCP) joint and is associated with differences between terrestrial (higher DC) and arboreal (lower DC) locomotor behaviors in quadrupedal taxa. While the degree of DC in both the foot and hand has traditionally been investigated at the genus level, relatively little research has examined its utility in detecting more nuanced locomotor differences among closely related species.

*Pongo pygmaeus* and *Pongo abelii* are closely related orangutan species that differ slightly in substrate use: *P. pygmaeus* engages in terrestrial locomotion more frequently, whereas *P. abelii* is predominantly arboreal [3]. This contrast provides a useful natural experiment for testing morphological correlates of habitual substrate preference. In fact, recent studies have shown that *P. pygmaeus* exhibits reduced proximal phalangeal curvature relative to *P. abelii*, consistent with increased terrestriality [4]. Here, we test the hypothesis that greater proximal articular surface angles (i.e., greater DC) is associated with terrestrial locomotion and predict that *P. pygmaeus* will exhibit greater angles in both the manual and pedal phalanges than *P. abelii*.

We used 3D landmarks to calculate proximal articular surface angles on paired manual and pedal phalanges from *P. pygmaeus* ( $n=14$ ) and *P. abelii* ( $n=16$ ), following established methods [1]. No specimen exhibited true dorsal canting (i.e.,  $<90^\circ$ ), but angles varied widely, reflecting differences in joint surface orientation. Manual phalanges showed no significant interspecific differences. However, pedal phalanges differed significantly with *P. pygmaeus* displaying higher average angles consistent with greater terrestriality. Compared to published values, both species exhibit pedal angles below the range reported for other hominoids, underscoring the role of a more plantarly canted proximal articular surface for habitual pedal grasping over facultative terrestrial locomotion [1].

Overall, our findings in pedal phalanges suggest that while absolute proximal articular surface orientations in *P. pygmaeus* are not dorsally canted and thus do not reflect terrestrial locomotion as they do in humans, interspecific differences among *Pongo* species suggest that this morphology may still serve as informative indicators of relative substrate use and provide a useful framework for interpreting early hominin foot biomechanics.

References: [1] Latimer, B., Lovejoy, C.O., 1990. Metatarsophalangeal joints of *Australopithecus afarensis*. American Journal of Physical Anthropology. 83, 13–23. [2] Rein, T.R., McCarty, L.A., 2012. Metacarpophalangeal Joint Orientation in Anthropoid Manual Phalanges. The Anatomical Record. 295, 2057–2068. [3] Thorpe, S.K.S., Crompton, R.H., 2006. Orangutan positional behavior and the nature of arboreal locomotion in Hominoidea. American Journal of Physical Anthropology. 131, 384–401. [4] Wennemann, S.E., Lewton, K.L., Orr, C.M., Almécija, S., Tocheri, M.W., Jungers, W.L., Patel, B.A., 2021. A geometric morphometric approach to investigate primate proximal phalanx diaphysis shape. American Journal of Biological Anthropology. 177, 581–602.

Poster Presentation Number 165, Session 2, Friday 14:00 - 15:30

## Comparative analysis of sexual dimorphism in the dentine morphology of permanent canines in Neanderthals and modern humans

Cecilia Yacobi Izquierdo<sup>1,2</sup>, Cecilia García-Campos<sup>1,2</sup>, María Martínón-Torres<sup>2,3</sup>, Marina Martínez de Pinillos<sup>1</sup>, Laura Martín-Francés<sup>2,4</sup>, Bernárdo Perea Perez<sup>6</sup>, Daniel García-Martínez<sup>5,7</sup>

1 - Departamento de Biología, Facultad de Ciencias, Universidad Autónoma de Madrid, Madrid, Spain · 2 - Centro Nacional de Investigación sobre la Evolución Humana, Burgos, Spain · 3 - Department of Anthropology, University College of London, London, UK · 4 - Monash Biomedicine Discovery Institute, Department of Anatomy and Developmental Biology, Monash University, Melbourne, Australia · 5 - Physical Anthropology Unit, Department of Biodiversity, Ecology, and Evolution, Faculty of Biological Sciences, Complutense University of Madrid, Madrid, Spain · 6 - Laboratorio de Antropología Forense, Escuela de Medicina Legal y Forense, Universidad Complutense de Madrid, Spain · 7 - Laboratory of Forensic Anthropology, Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Coimbra, Portugal

Various studies have focused on the differences in the dentition of hominin fossils, such as *Homo neanderthalensis*, in comparison with populations of *Homo sapiens*, showing important morphological differences. Recent studies demonstrate that the enamel-dentine junction (EDJ) morphology is closely related to the enamel surface, facilitating the examination of coronal morphology even when the enamel surface is worn, which is common in fossil remains [1]. The most notable aspect of this work is our focus on the study of dentin, whose conservative nature is key to demonstrating the relevance and usefulness of the internal morphology of the tooth from a taxonomic point of view. On the other hand, studies in dental anthropology on sexual dimorphism, both in contemporary and past human populations, have focused on evaluating the dimensions and external surface of the enamel of canines, considered the most sexually dimorphic tooth type. In this work, we compared the morphology of the EDJ of permanent canines of contemporary humans with that of the Krapina Neanderthals (Croatia), giving special attention to the evaluation of the sexual dimorphism present in the morphology of the EDJ in the Neanderthal sample. Our results indicate significant similarities and differences between maxillary and mandibular canines of *H. sapiens* and Neanderthals, particularly at the apical level and the basal region in both maxillary and mandibular canines, giving the Krapina teeth a pronounced shovel shape, and, in case of mandibular canines, a pointier general morphology with sharper edges. In terms of sexual dimorphism, the canines of Krapina are larger than those of *H. sapiens*, regardless of sex [2]. Within Krapina, a morphological pattern similar to that of *H. sapiens* is observed, with canines considered to belong to female individuals presenting a less elongated and more rounded EDJ with less developed crests, while those of males are elongated, with a wide, long, and pointed apex, and marked lingual crests highlighting once again the distal accessory ridge, as it happened in *H. sapiens* [3,4].

This study has been supported by the Dirección General de Investigación of the Spanish Ministerio de Economía y Competitividad (MINECO /FEDER) grant number: PID2021 122355NB-C33 and The Leakey Foundation through the personal support of G. Getty (2013) and D. Crook (2014-2020) to M. M.-T. The micro-CT images were obtained in the Laboratory of Microscopy of the CENIEH-ICTS (Spain) in collaboration with CENIEH staff. We also thank C. Tuniz, C. Zanoli, and F. Bernardini (ICTP) for their kind help with the micro-CT scanning of specimens. The micro-CT instrument of the ICTP was funded by the Regione Friuli-Venezia Giulia in the frame of the EXACT Project.

References: [1] García-Campos, C., Yacobi Izquierdo, C., Modesto-Mata, M., Martín-Francés, L., Martínez de Pinillos, M., Martínón-Torres, M., Perea Perez, B., Bermúdez de Castro, J.M., García-Martínez, D., 2024. Sexual dimorphism in the enamel-dentine junction (EDJ) of permanent canines of European modern humans. *American Journal of Biological Anthropology*. 184. [2] Yacobi Izquierdo, C., García-Martínez, D., García-Campos, C., 2024. Estudio del dimorfismo sexual de la superficie union esmalte dentina (EDJ)S de los caninos permanentes de *H. neanderthalensis*. *Zubia*. 42, 341-348. [3] Kaul, V., Prakash, S., 1981. Morphological features of Jat dentition. *American Journal of Physical Anthropology*. 54, 123-127. [4] Scott, G. R., 1977. Classification, sex dimorphism, association, and population variation of the canine distal accessory ridge. *Human Biology*. 49, 453-469.

Poster Presentation Number 166, Session 2, Friday 14:00 - 15:30

## **Thin on the mountainous landscape: the Late Pleistocene zooarchaeology of the southern Caucasus, Zagros, and Alborz**

**Reuven Yeshurun<sup>1</sup>**

1 - University of Haifa

Only a handful of examples speak for Middle and Upper Paleolithic adaptations to mid-latitude highlands. Mountainous southwest Asia, consisting of the southern Caucasus (including the Armenian Plateau) and the Zagros and Alborz ranges, is arguably the richest, featuring numerous Late Pleistocene (ca. 130–12 ka) archaeological records. The region's long zooarchaeological research history and especially the data gathered during the last two decades are now sufficient to support a study of Neanderthal and modern human subsistence and mobility patterns. I present a synthesis of the available zooarchaeological data from the southern Caucasus and the Zagros/Alborz. Using abundance indices of animal groups and taphonomic variables, I test the null hypothesis that humans hunted the available game proportionally to its abundance on the landscape. To this end, the natural abundance baselines were extrapolated from bioclimatic variables and nonhuman-generated Pleistocene faunas. Taphonomic and taxonomic patterns that pertain to site-occupation intensity were evaluated against a pertinent external reference, the well-studied zooarchaeological record of the southern Levant, representing a warmer and more habitable region.

The null hypothesis was only partially confirmed, enabling the identification of prey choice patterns, hunting specialization, and diversification. While acknowledging the region's archaeological variability, the study showed that the Middle and Upper Paleolithic habitations in the southern Caucasus and Zagros/Alborz were primarily ephemeral, attesting to low site habitation intensity and little, if any, population growth. It seems that all groups inhabiting the region could afford to practice highly selective game procurement strategies, exploiting vast territories and occupying many short-term camps, some strategically positioned to intercept migrating game. Both Middle and Upper Paleolithic populations consisted of small and highly mobile groups that sporadically inhabited the rugged landscape; they lived under harsh climatic conditions well under the environmental carrying capacity. This scenario contributes to viewing mountainous southwest Asia as a geographic cul-de-sac during the Pleistocene; it demonstrates that regardless of their biological and cultural backgrounds, human groups adopted similar behaviors in accordance with the regions' natural conditions.

References: [1] Yeshurun, R., 2025. Thin on the mountainous landscape: The Late Pleistocene zooarchaeology of the southern Caucasus, Zagros, and Alborz. *Quaternary Science Reviews*. 357, 109325.

Poster Presentation Number 167, Session 2, Friday 14:00 - 15:30

## How ancestral patterns of variation shed light on the evolution of the contemporary human condition: leveraging disease phenotype associations in paleogenomics

Elif Yildiz<sup>1,2,3</sup>, Yulia Yakubenkova<sup>4</sup>, Cedric Boeck<sup>5,6,7</sup>

1 - Max Planck School of Cognition · 2 - Max Planck Institute for Psycholinguistics · 3 - Max Planck Institute for Evolutionary Anthropology · 4 - Universitat Pompeu Fabra · 5 - University of Barcelona, Section of General Linguistics · 6 - University of Barcelona, Institute for Complex Systems · 7 – ICREA

The shift in perspective to characterize the genetic basis of human condition “as a combination of genetic features, where perhaps none of them is present in each and every present-day individual” [1] opens many possibilities to scrutinize the nature of high-frequency, nearly fixed variants in modern human genomes through the effect of the minor alleles, either present in extant Pan relatives (“basal”), or “derived” in the genomes of extinct hominins. Here we present the results of intersecting a comprehensive catalog of such loci (building on [2]) with the ClinVar and Gnomad databases, which provide associations with disease phenotypes, valuable to infer functional impacts. We do so to gain a deeper understanding of the effect of now-dominant alleles in contemporary human populations; in particular, to detect which “cellular” phenotypes may be most derived.

The resulting list of close to 2000 loci is evenly distributed across contemporary human genomes. Recurrent disease associations highlight terms with sensorimotor processing and ataxia. Examining the nature of these variants in the Gtex database reveals a significant enrichment for the cerebellum, a finding that is further reinforced by a Gene Ontology pathway analysis, which brings out metabolic terms specific to the cerebellum, as well as specific cell types exclusive to the cerebellum. These cerebellar-specific enrichments we observe may support previous proposals that certain cerebellar development patterns play a role in characterising the evolutionary trajectory of *Homo sapiens*, including the prolonged postnatal maturation, relative expansion, and more globular shape of the cerebellum compared to both our extant and extinct closest relatives [3].

In contrast to minor alleles traceable to the *Pan* lineage (“basal variation”), minor alleles that are derived in extinct hominin genomes are found in highly constrained genomic regions in the Gnomad database, associated with neurodevelopmental disorders, and are in general depleted of brain-specific effects in the Gtex database. Supporting this, statistical modeling revealed that brain tissues exhibited stronger regulatory effects than non-brain tissues, as reflected in greater absolute normalized effect sizes. Taken together our results add further evidence to the relevance of the cerebellum and brain-metabolic pathways to characterize the human condition.

References: [1] Zeberg, H., Jakobsson, M., Pääbo, S., 2024. The genetic changes that shaped Neandertals, Denisovans, and modern humans. *Cell*. 187, 1047–1058. [2] Kuhlwilm, M., Boeckx, C., 2019. A catalog of single nucleotide changes distinguishing modern humans from archaic hominins. *Scientific Reports*. 9. [3] Neubauer, S., Hublin, J.-J., Gunz, P., 2018. The evolution of modern human brain shape. *Science Advances*. 4.

Podium Presentation, Session 10, Saturday 15:50 – 17:10

## Endostructural investigation of the Middle Pleistocene craniodental remains from Kabwe, Zambia

Clément Zanolli<sup>1,2</sup>, Alessandro Urciuoli<sup>3,4,5,6</sup>, Laura Martin-Francés<sup>7,8</sup>, Xing Song<sup>9,10</sup>, María Martín-Torres<sup>7</sup>, Mercedes Conde-Valverde<sup>5,11</sup>, Juan Luis Arsuaga<sup>12,13</sup>, Thomas Colard<sup>1</sup>, Tony Chevalier<sup>14,15</sup>, Yameng Zhang<sup>16,17</sup>, Xijie Wu<sup>9</sup>, Chris Stringer<sup>18</sup>

1 - Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France · 2 - Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa · 3 - Institut of Paleontology, University of Zurich, Zürich, Switzerland · 4 - Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici ICTA-ICP, c/ Columnes s/n, Campus de la UAB, Barcelona, Spain · 5 - Universidad de Alcalá, Cátedra de Otoacústica Evolutiva y Paleoantropología (HM Hospitales-UAH), Departamento de Ciencias de la Vida, Madrid, Spain · 6 - Division of Palaeoanthropology, Senckenberg Research Institute and Natural History Museum Frankfurt, Frankfurt am Main, Germany · 7 - Centro Nacional de Investigación sobre la Evolución Humana, Burgos, Spain · 8 - Monash Biomedicine Discovery Institute, Department of Anatomy and Developmental Biology, Monash University, Melbourne, Australia · 9 - Key Laboratory of Vertebrate Evolution and Human Origins, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China · 10 - CAS Center for Excellence in Life and Palaeoenvironment, Beijing, China · 11 - Department of Anthropology, Binghamton University (SUNY), Binghamton, NY, USA · 12 - Centro Mixto UCM-ISCIH de Investigación sobre Evolución y Comportamiento Humanos, Madrid, Spain · 13 - Departamento de Geodinámica, Estratigrafía y Paleontología, Universidad Complutense de Madrid, Madrid, Spain · 14 - Université de Perpignan via Domitia, Perpignan, France · 15 - UMR 7194 CNRS, Histoire Naturelle de l'Homme Préhistorique (HNHP, MNHN), Centre européen de recherches préhistoriques, Tautavel, France · 16 - Joint International Research Laboratory of Environmental and Social Archaeology, Shandong University, Qingdao, China · 17 - Institute of Cultural Heritage, Shandong University, Qingdao, China · 18 - Centre for Human Evolution Research, The Natural History Museum, London, United Kingdom

The cranium labeled NHMUK PA E 686 (a.k.a. Broken Hill 1 or Kabwe; hereafter abbreviated as E686) and the maxilla NHMUK PA E 687 (a.k.a. Broken Hill 2, abbreviated below as E687) were found between 1921 and 1925 by lead miners near Kabwe (formerly known as Broken Hill), in Zambia [1]. Direct uranium-series dating on E686 recently provided an age of ~300 ka [2]. The maxilla E687 was not dated, and its external morphology appears more *H. sapiens*-like than E686, raising questions about whether both specimens come from the same chronostratigraphic level, and/or represent the same species.

The taxonomy of these fossils, especially of E686, is highly debated. Attributed to *Homo rhodesiensis* in 1921 by Woodward, E686 was subsequently lumped into *Homo heidelbergensis* based on similarities in cranial morphology with European specimens attributed to the latter taxon (in particular Petralona) [3]. Recently, *Homo bodoensis* was erected to accommodate African fossils, including E686, but this proposal does not solve the taxonomic conundrum around the Kabwe fossils [4]. A recent analysis of cranial bone thickness, facial morphology and sinuses, and endocranial morphology suggested that E686 retains several structural features of *H. erectus/ergaster*, but remained inconclusive regarding its taxonomy [5]. The aim of this study is to provide evidence from two taxonomically and phylogenetically informative structures—namely, the teeth and inner ear—to assess whether E686 and E687 could belong to the same taxon and clarify their phylogenetic affinities within *Homo*.

Following the segmentation of the microCT scans of E686 and E687, we conducted geometric morphometric analyses of the enamel-dentine junction (EDJ) of the preserved maxillary M2 and M3, and of the semicircular canals (SC) using a 3D diffeomorphic surface matching approach. We compared the Zambian material with Pleistocene specimens attributed to *H. ergaster*, *H. erectus*, *H. antecessor* (EDJ only), *H. neanderthalensis*, and *H. sapiens*. Principal component analyses, between-group principal component analyses (bgPCA), and typicality probabilities were computed.

The results of the analyses of the EDJ indicate that the molars of the two specimens E686 and E687 approximate the morphology of *H. sapiens*, showing a taller topography than Early Pleistocene *Homo* specimens, and differing from *H. neanderthalensis* by their more peripherally-positioned dentine horns and less expanded hypocone. Typicality probabilities computed on the bgPCA scores classify both specimens as *H. sapiens* or as an outlier for E686 M2. The signal expressed by SC shape appears intermediate between *H. sapiens* and *H. neanderthalensis*, sharing with the latter a high sagittal index (a superiorly positioned lateral canal relative to the posterior canal), while lacking the thick SCs found in the latter species. The typicality probabilities computed on the bgPCA scores suggest E686 is an outlier for all the considered groups except *H. neanderthalensis*.

In both analyses of the EDJ and SC, no affinities with earlier *Homo* species were recovered, but our results show a mix of *H. sapiens*- and *H. neanderthalensis*-like traits. It is possible that the Kabwe specimens represent a group ancestral to both of the latter species, or a species closely related to their ancestor. Clarifying the polarity of the feature presented here will require a complete revision of the African Middle Pleistocene human record, integrating evidence from the internal structure of the bones and teeth. However, due to the scarcity of comparative data, finding more fossils from this chronogeographic range will likely be the key to resolve the taxonomy of the Kabwe human remains, as well as to better understand the evolution of later *Homo* in Africa, and in particular the origins of *H. sapiens*.

Natural History Museum of London, CENIEH Burgos, Ditsong Museum of Natural History, Senckenberg Research Institute, and Natural History Museum, [human-fossil-record.org](http://human-fossil-record.org), [archiv.neanderthal.de](http://archiv.neanderthal.de), [palco.csr.fr](http://palco.csr.fr), [morphosource.org](http://morphosource.org). This project received funding from: PACEA Laboratory (AFRIQUE team, UMR 5199), CNRS, University of Bordeaux's IdEx "Investments for the Future" program/GPR "Human Past", R+D+I projects PID2020-116908GB-I00, and PID2021-122355NB-C31 and C33 (MCIN/AEI/10.13039/501100011033/FEDER, UE), CERCA Programme/Generalitat de Catalunya, European Union-NextGenerationEU. Chris Stringer's research is supported by the Calleva Foundation and the Human Origins Research Fund. L.M-F receives funding from the EU-Horizon Program-Marie Skłodowska-Curie Actions of the EU Ninth programme (2021–2027) under the HORIZON-MSCA-2021-PF-01-Project: 101060482. We are grateful to the National Center for Scientific Research (CNRS)/IN2P3 Computing Center (Lyon, France) and to the LOEWE Centre for Translational Biodiversity Genomics, Frankfurt am Main, Germany for providing GPU computational power.

References: [1] Schwartz, J.H., Tattersall, I., 2003. The Human Fossil Record. Craniodental Morphology of Genus *Homo* (Africa and Asia), vol. 2. Wiley-Liss, Hoboken. [2] Grün, R., Pike, A., McDermott, F., Eggins, S., Mortimer, G., Aubert, M., Kinsley, L., Joannes-Boyau, R., Rumsey, M., Denys, C., Brink, J., Clark, T., Stringer, C., 2020. Dating the skull from Broken Hill, Zambia, and its position in human evolution. *Nature*. 580, 372–375. [3] Stringer, C., 2012. The status of *Homo heidelbergensis* (Schoetensack 1908). *Evolutionary Anthropology*. 21, 101–107. [4] Bae, C.J., Aiello, L.C., Hawks, J., Kaifu, Y., Lindal, J., Martínón-Torres, M., Ni, X., Posth, C., Radović, P., Reed, D., Schroeder, L., Schwartz, J.H., Silcox, M.T., Welker, F., Wu, X.-J., Zanolli, C., Roksandic, M., 2024. Moving away from “the Muddle in the Middle” towards solving the Chibanian puzzle. *Evolutionary Anthropology*. 33, e22011. [5] Balzeau, A., Buck, L.T., Albessard, L., Becam, G., Grimaud-Hervé, D., Rae, T.C., Stringer, C.B., 2017. The internal cranial anatomy of the Middle Pleistocene Broken Hill 1 cranium. *PaleoAnthropology* 2017, 107–138.

Poster Presentation Number 168, Session 2, Friday 14:00 - 15:30

## Clues from the Upper Limbs: new morphometric evidence for locomotor behaviour in *Oreopithecus bambolii*

Carlotta Zeppilli<sup>1</sup>, Tommaso Pastorelli<sup>1</sup>, Damiano Marchi<sup>1</sup>, Giovanni Boschian<sup>1</sup>, Andrea Faggi<sup>2</sup>, Simone Farina<sup>3</sup>, Eishi Hirasaki<sup>4</sup>, Andrea Savorelli<sup>5</sup>, Luca Bellucci<sup>6</sup>, Jacopo Moggi-Cecchi<sup>7</sup>, Lorenzo Rook<sup>2</sup>, Marco Cherin<sup>8</sup>, Alessandro Riga<sup>7</sup>, Antonio Profico<sup>1</sup>

1 - Department of Biology, University of Pisa · 2 - Department of Earth Sciences, University of Florence · 3 - Natural History Museum of the University of Pisa · 4 - Center for the Evolutionary Origins of Human Behavior, Kyoto University · 5 - Museum of Geology and Paleontology, University Museum System, University of Florence · 6 - Natural History Museum Abu Dhabi, Department of Culture and Tourism, Nation Towers Corniche, Abu Dhabi, United Arab Emirates · 7 - Department of Biology, University of Florence · 8 - Department of Physics and Geology, University of Perugia

*Oreopithecus bambolii* Gervais, 1872 is a Late Miocene hominoid that has long intrigued paleoanthropologists mainly concerning its locomotor adaptations, manipulative capabilities, and phylogenetic position as well. *Oreopithecus* inhabited the stable, insular ecosystem of the Tyrrhenian region during the Miocene which at the time was an archipelago formed by the fragmentation of the mainland. Within the context of its geographic isolation, *Oreopithecus* showed distinctive morphological traits that set it apart from both extant and extinct relatives. Fossils of this species, discovered primarily in the lignite deposits of Tuscany and Sardinia (Italy), provide a valuable opportunity to investigate the evolutionary trajectories of European hominoids during the Miocene. The best-preserved specimen is IGF 17788, known as “Sandrone,” housed at the Geological and Paleontological Museum of Florence (Italy). In the present study, a comprehensive morphometric approach was adopted to examine the postcranial anatomy of *Oreopithecus* with the aim of shedding further light mainly on its locomotor behaviour. Digital acquisition and 3D modelling techniques were used to mitigate the effects of taphonomic deformation and to allow for more reliable quantitative comparisons. Both linear and geometric morphometric data were collected and analysed. Linear morphometric analyses were carried out on several cranial and postcranial elements, including the mandible, upper limbs, hand, and femur. Despite the relatively large body size of *Oreopithecus*, its limb proportions align it more closely with small-bodied apes such as gibbons (Hylobatidae). The principal component analysis (PCA), conducted on the surface areas of the humeral head and the greater and lesser tubercles across 61 primate genera, positioned *Oreopithecus* within extant primates involved in suspensory behaviour to various degrees, such as Hylobatidae, Ponginae and Atelinae. Concerning the hand, the geometric morphometric analysis of the scaphoid was carried out, due to its role in inferring locomotor behaviour. Hominoids exhibiting a fused scaphoid–central complex (e.g., *Pan*, *Gorilla*, *Homo*) were excluded from this analysis to ensure anatomical homology and comparability. The morphology of the *Oreopithecus* scaphoid showed strong affinities with that of *Pongo*, echoing previous observations in the literature. Additionally, its trajectory in morphospace closely mirrors that of Hylobatidae. In summary, the upper-to-lower limb linear proportions and the morphometric analysis of the postcranial skeleton of *Oreopithecus bambolii* may suggest a hominoid mainly involved in forelimb-dominated suspension, broadly similar to Asian apes. These findings contribute to a broader understanding of hominoid diversity and adaptation during the Miocene. Future research will focus on additional postcranial elements of *Oreopithecus bambolii*, including vertebrae, metacarpals, and other carpal bones, which may provide further evidence on the locomotor adaptations of this Miocene hominoid inhabiting a complex insular ecosystem and its phylogenetic positioning as well.

Podium Presentation, Session 4, Friday 08:30 – 10:30

## Toward scalable AI-powered analysis in paleoanthropology: from 3D refitting stones and bones to microwear analysis

Jing Zhang<sup>1,2</sup>, Sihang Li<sup>1</sup>, Zeyu Jiang<sup>1</sup>, Irving Fang<sup>1</sup>, Juexiao Zhang<sup>3</sup>, Chenyang Xu<sup>3</sup>, Hao Wu<sup>1</sup>, Xue Wang<sup>2</sup>, Shannon P. McPherron<sup>4</sup>, Danielle MacDonald<sup>5</sup>, Chen Feng<sup>1</sup>, Radu Iovita<sup>2</sup>

1 - New York University Tandon School of Engineering, Center for Robotics and Embodied Intelligence · 2 - New York University, Center for the Study of Human Origins, Department of Anthropology · 3 - New York University, Courant Institute of Mathematical Sciences · 4 - Max Planck Institute for Evolutionary Anthropology, Department of Human Origins · 5 - University of Tulsa, Department of Anthropology

The analysis of stone artifacts and bone materials remain central to paleoanthropology, yet plagued by the fragmentation inherent to the archaeological record. Traditional approaches to refitting in both lithic and faunal domains, as well as the interpretation of microwear patterns are time-consuming, subjective, labor-intensive, and often irreproducible at scale. We present two complementary AI-powered frameworks that focus on these challenges from the macro to the micro level.

First, we introduce a generalizable 3D refitting framework that addresses the inherent challenges of assembling fragments, including irregular breakage, missing pieces, and extraneous material. Our method employs large-scale fracture-aware pretraining, which means leveraging surface segmentation to learn what fractures look like. It integrates flow matching for precise pose estimation (estimating where the fragment fits in the complete object shape) and adopts fine-tuning on lithic- and bone-specific fracture types to improve generalization. This approach achieves state-of-the-art performance in both simulated and real-world fracture scenarios and remains effective even when fragments are missing or incorrectly grouped [1]. Additionally, we improve the published Virtual Knapper algorithm [2] to generate cores and flakes and break them virtually to train the refitting algorithm to recognize and reassemble conjoiners.

Second, we present LUWA (Lithic Use-Wear Analysis), the first large-scale, open-source dataset for microscopic lithic wear classification [3]. LUWA contains over 23,000 high-resolution images captured across multiple magnifications and sensing modalities (texture and heightmap). These images represent both human- and machine-generated use-wear patterns across a variety of worked materials, such as bone, ivory, leather, and several types of wood. We employ transfer learning and few-shot learning based on foundation models instead of training small models from scratch. Transfer learning involves the transfer of knowledge from foundation models trained on internet-scale datasets to tasks involving new, specialized datasets, and few-shot learning is similar to the process by which a human expert uses a few examples and their experience to make a guess. To compare their performance, we benchmark a range of computer vision models—from classic architectures to modern foundation models such as DINOv2—and show that foundation models significantly outperform small models and human experts in classification accuracy. To further push the frontier of interpretability, we introduce a visual question answering (VQA) setup using vision-language models (e.g., GPT-4V), enabling exploratory analysis of where to look and what to infer from microscopic evidence, mimicking expert reasoning. Together, these tools demonstrate the potential of AI-driven approaches to enhance the scalability, accuracy, and reproducibility of a large swath of paleoanthropological analysis.

The work on LUWA is supported by NSF Grant 2152565, and by NYU IT High-Performance Computing resources, services, and staff expertise. We gratefully acknowledge Dr. Rakesh Behera for the tribometer hardware, and thank Sara Borsodi, Felix Devis Kisenia, Kat Liu, Eugenia Ochoa, Vita Jackman Kuwabara, Alice Jiang, Meiyu Zhang, and Sriram Koushik for their valuable assistance in collecting the microscopic images. For the work on refitting we gratefully acknowledge the Physical Anthropology Unit, Universidad Complutense de Madrid for access to skeletal material, and Dr. Scott A. Williams (NYU Anthropology Department) for the processed data samples. This work was supported in part through NSF grants 2152565, 2238968, 2322242, and 2426993, and the NYU IT High Performance Computing resources, services, and staff expertise.

References: [1] Li, S., Jiang, Z., Chen, G., Xu, C., Tan, S., Wang, X., Fang, I., Zyskowski, K., McPherron, S.P., Iovita, R., Feng, C., Zhang, J., 2025. GARF: Learning Generalizable 3D Reassembly for Real-World Fractures. [2] Orellana Figueroa, J.D., Reeves, J.S., McPherron, S.P., Tennie, C., 2021. A proof of concept for machine learning-based virtual knapping using neural networks. *Scientific Reports*. 11. [3] Zhang, Jing, Fang, I., Wu, H., Kaushik, A., Rodriguez, A., Zhao, H., Zhang, Juexiao, Zheng, Z., Iovita, R., Feng, C., 2024. LUWA Dataset: Learning Lithic Use-Wear Analysis on Microscopic Images. 2024 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR). 22563–22573.

Poster Presentation Number 169, Session 2, Friday 14:00 - 15:30

## A voxel-based method for reconstruction of mass distribution in human skulls

Ziliang Zhang<sup>1</sup>, Laura C. Fitton<sup>1,2</sup>

1 - Department of Archaeology, University of York, York, UK · 2 - Centre for Anatomical and Human Sciences, Hull York Medical School, University of York, York, UK

Head balance and posture are considered critical components of hominin locomotor efficiency. During the evolutionary transition from *Australopithecus* to early *Homo*, and subsequently to later *Homo*, cranial morphology underwent significant changes: jaws and teeth reduced in size, facial prognathism diminished, and brain volume increased alongside cranial globularisation. These shifts likely influenced the centre of mass (CoM) and head mass distribution (MD), yet few studies have investigated how such anatomical changes interact to affect cranial biomechanics.

This study presents a novel voxel-based method for virtually reconstructing cranial MD in the sagittal plane and estimating CoM in human skulls using CT imaging and tissue-specific density values. The aim is to develop a validated model that can ultimately be applied to fossil hominins to investigate evolutionary trends in cranial balance.

Three modern human crania were analysed: two adults (one scanned via micro-CT, one via medical CT) and one neonate (micro-CT). Skulls were aligned and a custom ImageJ macro was used to convert slices from the CT stack into voxel grayscale numerical output, which was then assigned tissue densities based on published values. This allowed calculation of mass per slice, which was cumulatively summed to determine the CoM and assess MD in relation to anatomical landmarks, including the occipital condyles.

To optimise the modelling approach, a series of sensitivity analyses were performed, including validation against physical measurements of CoM and total mass using a two-scale experimental setup. Digital models were constructed and analysed using several methods: 12-bit Hounsfield unit conversion, 12-bit and 8-bit grayscale values, and manual assignment of average densities to segmented materials (bone and teeth). The predicted CoM and MD from each method were compared with empirical measurements from physical specimens (*ex vivo*). Segmentation was carried out in 3D Slicer, while ImageJ and Microsoft Excel were used for mass reconstruction. Sensitivity testing also evaluated the influence of scan resolution, specimen age, and assumed tissue densities.

Results indicate that CoM and mass estimates in adult skulls are robust across scan resolutions but are sensitive to construction method and tissue density values. Although total mass estimates varied across methods, CoM positions remained broadly consistent. Grayscale fitting proved to be the most valid approach; however, direct density assignment to the segmented models also produced accurate results and can therefore be recommended for application to fossil material. This is especially useful as estimates of material densities and homogenisation of materials would be required. The neonatal model showed reduced accuracy, likely due to scan artefacts and resolution limitations arising from the thinness of neonatal cranial bones.

In summary, this voxel-based method provides a powerful tool for quantifying cranial mass properties in both extant and extinct hominins. Its application to fossil specimens will enable new insights into how facial reduction, brain expansion, and cranial reorganisation influenced head balance and locomotor adaptations during hominin evolution.



This work is distributed under the terms of a [Creative Commons Attribution-NonCommercial 4.0 Unported License](https://creativecommons.org/licenses/by-nc/4.0/).