

# PALEOANTHROPOLOGY SOCIETY MEETING ABSTRACTS, HONOLULU, HI, 2-3 APRIL 2013

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## Latest Miocene Hominin From Kenya, *Orrorin tugenensis*, Exhibits Intermediate Femoral Morphology Between Earlier Miocene Apes and Later Bipedal Hominins

Sergio Almécija, *Anatomical Sciences, Stony Brook University, USA*  
Melissa Tallman, *Biomedical Sciences, Grand Valley State University, USA*  
David Alba, *Institut Català de Paleontologia Miquel Crusafont, SPAIN*  
Marta Pina, *Institut Català de Paleontologia Miquel Crusafont, SPAIN*  
Salvador Moyà-Solà, *Institut Català de Paleontologia Miquel Crusafont, SPAIN*  
William Jungers, *Anatomical Sciences, Stony Brook University, USA*

*Orrorin tugenensis* (Kenya, ca. 6 Ma) is one of the earliest putative hominins in the fossil record. The *Orrorin* hypodigm includes three partial femora, with one of them—BAR 1002'00—preserving most of its proximal morphology and exhibiting inferred adaptations for terrestrial bipedalism. This specimen was originally described as being very human-like, even more so than later hominins, although subsequent multivariate analyses showed that it actually shares a distinctive shape with australopiths. However, some traits of this femur (e.g., greater and lesser trochanteric form) recall the morphology seen in earlier Miocene apes. Here we reassess the morphological affinities of BAR 1002'00 using three-dimensional geometric morphometrics (13 coordinates covering functionally meaningful landmarks of the proximal femur), within an extensive sample of modern humans, great apes, and hylobatids, as well as with fossil hominins, and—for the first time—Miocene apes. Since Miocene apes have been described by some as monkey-like for certain features, we also included a broad sample of cercopithecoïd and platyrrhine monkeys (N of total sample=448). Our multivariate results (based on between-group principal components analysis [bgPCA] and phylogenetic methods) indicate that platyrrhines, cercopithecoïds, and hominoids can be reliably distinguished from each other, thereby indicating a strong phylogenetic signal in the shape data ( $p < 0.0001$ ). Our results also demonstrate that Miocene apes are more similar to extant apes than to any extant monkey. A bgPCA focused on hominoids only reveals that BAR 1002'00 displays strong shape affinities with the earlier Miocene apes, being intermediate between them and some australopiths. Extant great apes, and especially chimpanzees and bonobos, display a distinct and probably derived morphology. These results suggest that some Miocene apes could closely approximate the proximal femoral anatomy of the last common ancestor of hominins and African apes. *Orrorin* apparently preserves aspects of this ancestral shape.

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## Smaller Things Remembered: Ostrich Eggshell Technology, Taphonomy and Geochemistry in Kenya

Stanley H. Ambrose, *Anthropology, University of Illinois, USA*  
Philip A. Slater, *Anthropology, University of Illinois, USA*

The appearance of engraved ostrich eggshell (OES) canteens around 65 ka in southern Africa, and beads by 50–45 ka in eastern and southern Africa, represent significant milestones in the evolution of modern human technology and symbolic behavior. Methods for describing OES artifacts, thermal alteration, and criteria for identifying natural damage and use-wear on canteens are not systematically applied, hindering comparative analyses. We present a preliminary descriptive analysis system for OES using >40 ka and mid-Holocene Later Stone Age (LSA) OES assemblages from Enkapune Ya Muto Rockshelter, Kenya. Comparison to the >40 ka bead assemblage from Border Cave, South Africa, shows that the earliest LSA beads in both regions have irregular faceted perimeters from chipping and grinding on flat surfaces. Mid-Holocene beads have more symmetric rounded perimeters, indicating grinding in grooved stones. Kalahari foragers often recycled OES canteen fragments for bead manufacture. Beaded artifacts were transported up to 200km in reciprocal gift exchange networks. Canteens were likely also transported long distances before discard. Bead and canteen fragment geochemical fingerprinting may provide evidence for the scale of logistic/residential mobility and reciprocal exchange networks where there is systematic strontium isotope variation across the landscape. Carbon and oxygen isotopes can distinguish OES fragments from different eggs with similar strontium isotope ratios, and provide environmental and climatic data. Initial results on modern OES fragments and beads in northern, central, and southern Kenya, and MSA and LSA fragments from central and southern Kenyan sites, show significant strontium, carbon, and oxygen isotopic diversity within strings of beads, and systematic differences between regions. Oxygen isotopes also distinguish dry from wet regions. We conclude that more experimental, microscopic, and geochemical research is needed to realize the great potentials of archaeological OES assemblages to provide evidence for the evolution of modern human behavior and cognition in Africa.

## Paleoenvironments and Settlement Dynamics at the Druze Marsh Paleolithic Site in Northeast Jordan

Christopher Ames, *Department of Anthropology, McGill University, CANADA*  
 April Nowell, *Department of Anthropology, University of Victoria, CANADA*  
 Carlos Cordova, *Department of Geography, Oklahoma State University, USA*  
 Michael Bisson, *Department of Anthropology, McGill University, CANADA*  
 James Pokines, *Department of Anatomy and Neurobiology, Boston University School of Medicine and Forensic Anthropology, USA*

Situated along an important crossroads for hominin dispersals into Eurasia and Southwest Asia, the Druze Marsh, a wetlands in the Greater Azraq Oasis Area (GAOA) in northeast Jordan, was a locale of high biodiversity in an otherwise desertic/steppic landscape throughout the Pleistocene and early Holocene. Newly exposed sediments documenting the changing hydrology and climate of the region have allowed our team to begin studying changing dynamics of hominin settlement patterns in response to fluctuating climates and water availability. To date, our archaeological and geomorphological research in the now dry marsh bed has identified prehistoric occupations from the Late Lower Paleolithic, Middle Paleolithic, and Upper Paleolithic that correspond to relatively dry conditions when the Druze Marsh wetland was reduced in size. Separating these occupations are extended periods when the wetland increased in size and depth, expanding at times to a shallow lake, and drowning land previously available for hominin occupation, a situation that forced hominins into the surrounding uplands and along the river channels. Lithic analysis demonstrates that although most artifacts are in pristine condition, the context ranges from an *in situ* Middle Paleolithic occupation surface to substantially displaced assemblages caused by the shrink-swell of clayey sediments. Combining our results from the Druze Marsh with previously known Paleolithic finds in the Azraq Basin more broadly produces a spatially continuous, but compositionally heterogeneous, distribution of artifacts throughout the region. Evaluating the importance of the Druze Marsh at critical points in human prehistory, therefore, requires reconstructing the detailed history of Paleolithic settlement and land use by integrating the large body of archaeological remains distributed across varying geomorphic contexts with local and regional paleoenvironmental change.

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## Small Mammal Utilization by Middle Stone Age Humans at Die Kelders Cave 1, Western Cape, South Africa

Aaron Armstrong, *Department of Anthropology, University of Minnesota, USA*

Middle Stone Age (MSA) sites of southern Africa—with their preserved evidence of adaptive complexity such as symbolic behavior (Henshilwood et al. 2011; Texier et al. 2010) and innovative technologies (Brown et al. 2012; Wadley et al. 2009)—continue to shape our understanding of modernity and human behavioral evolution during the Later Pleistocene. While the symbolic and technological aspects of MSA material culture have received considerable attention, significant gaps exist in our understanding of the subsistence behavior of humans during this period. It is apparent that MSA humans actively hunted a variety of large mammals; however, remarkably little is known about the place of small, mobile prey in MSA life-ways despite their abundance at fossil sites. I will present data on the MSA small faunal component from Die Kelders Cave 1 (80–60 ka), a sample consisting of over 34,000 small mammal remains dominated by Cape dune mole-rat (*Bathyergus suillus*), Cape hare (*Lepus capensis*), and rock hyrax (*Procapra capensis*); small mammals account for ~80% of assemblage by NISP. New taphonomic evidence indicates that humans were primarily responsible for the accumulation of small mammals during periods of high-intensity cave occupation, whereas large nocturnal raptors were likely responsible for accumulations during periods of low-intensity occupation. Cut-marked and calcined small mammal bones indicate that humans directly interacted with small mammals and that these were a valuable component of the resource base. These results add new data to our understanding of broad spectrum foraging during the MSA of southern Africa and suggest that humans expanded their resource base to include small, mobile prey between 80–60 ka. As we have a limited understanding of these activities at present, studies of small mammal fossil assemblages are crucial to understanding developments in modern human behavioral complexity.

### References Cited:

- Brown, K.S. et al. 2012. An early and enduring advanced technology originating 71,000 years ago in South Africa. *Nature* 491(7425): 590–593.
- Henshilwood, C.S. et al. 2011. A 100,000-year-old ochre-processing workshop at Blombos Cave, South Africa. *Science* 334(6053): 219–222.
- Texier, P.-J. et al. 2010. A Howiesons Poort tradition of engraving ostrich eggshell containers dated to 60,000 years ago at Diepkloof Rock Shelter, South Africa. *Proceedings of the National Academy of Sciences USA* 107(14): 6180–6185.
- Wadley, L. 2009. Implications for complex cognition from the hafting of tools with compound adhesives in the Middle Stone Age, South Africa. *Proceedings of the National Academy of Sciences USA* 106(24): 9590–9594.

## More Insights From Above: Comparison of Upper Deciduous Second Molar and Permanent First Molar Morphology in *Homo neanderthalensis* and *Homo sapiens*

Shara Bailey, *CSHO/Department of Anthropology, New York University, USA*  
 Stefano Benazzi, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Claudia Astorino, *The Graduate Center, City University of New York & NYCEP, USA*  
 Kathleen Paul, *School of Human Evolution and Social Change, Arizona State University, USA*  
 Jean-Jacques Hublin, *Department of Human Evolution, Max Planck Institute, GERMANY*

Comparative dental studies often focus on the permanent first molar (M1) because it is presumed to be the most evolutionarily conservative of the permanent molars. Deciduous teeth, however, comprise a significant portion of the fossil record and in some cases are the only hominin remains recovered. The deciduous second molar (dm2) is considered the analogue of the permanent M1 and is generally thought to be morphologically similar. On the other hand, the dm2 is often considered to be even more phylogenetically conservative and/or under stronger genetic control than the M1 due to its early development. Therefore, while we expect the morphology of the two teeth to be significantly correlated, we predict the dissimilarity between dm2 and M1 to be higher in species with derived M1 morphology than in species that retain primitive M1 morphology. The shape of the upper M1 (UM1) serves as a test of this hypothesis since it has been suggested to be derived in Neandertals. Here we use geometric morphometric analysis to study oriented UM1 and upper dm2 (udm2) crown outlines of the same individuals. Our sample included 37 udm2/UM1 pairs: five *H. neanderthalensis*, seven fossil *H. sapiens* (30,000–10,000 BP), and 25 recent *H. sapiens* representing Europe, Southeast Asia, Africa, and the Americas. Principal Components Analysis (PCA) shows that the *H. sapiens* udm2/UM1 pair sample largely overlaps in shape space, whereas the Neandertal udm2s separate from UM1s along PC1. Indeed, Procrustes distances calculated between udm2/UM1 pairs showed that the average distance for *H. sapiens* (mean=0.032; range=0.022–0.046) was significantly lower ( $p=0.02$ ; permutation test,  $n=1000$ ) than the distances obtained for each individual *H. neanderthalensis* pair (mean=0.040; range=0.036–0.049). However, Partial Least Squares (PLS) analysis showed a similar pattern of covariation between Neandertal and *H. sapiens* udm2/UM1 pairs ( $r^2=0.471$ ;  $p<0.001$ ), suggesting that allometry may be responsible for the differences observed.

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## Symmetry in Levantine Mousterian Levallois points and the Implication for Neanderthal Cognition: Comparison between Two Analytical Methods

Colleen A Bell, *Anthropology, University of Tulsa, USA*  
 Donald Henry, *Anthropology, University of Tulsa, USA*  
 Miriam Belmaker, *Anthropology, University of Tulsa, USA*

The interaction between Neanderthal and Modern Humans during the MP/UP Transition raises the question of how the two taxa differed in cognitive abilities and if this played a role in the demise of the Neanderthals. It has been argued that the degree of standardization of symmetry within an assemblage can be used as a marker of cognitive ability (Hodgson 2009). However, other factors may lead to a similar pattern (Chase and Dibble 1986). Kerry and Henry (2000) studied the deviation from symmetry with an assemblage of Mousterian Levallois points from the site of Tor Faraj, Jordan (ca. 55 ka) using linear measurements. They concluded that the low standard deviation supports a high-level Neanderthal cognition. Crompton (2007) argued that linear measurements could not accurately capture symmetry in lithics, leaving room for reevaluation of the results. To test this hypothesis within a single assemblage, we present a comparative study using the two alternative methods of lithic analysis on a sub-sample from the Tor Faraj collection studied by Kerry and Henry (2007). We measured the deviation of symmetry within a single assemblage in a sample of 50 Levallois points following the protocol applied by Kerry and Henry (2000). Symmetry was measured by: 1) angle of deviation from direction of impact, 2) left versus right proportions from point of impact; and, 3) length, width, and thickness ratio. The same specimens were scanned in the Next Engine 3D scanner and symmetry was measured by aligning the computed center of gravity with maximum length. Results indicate discrepancies in deviation from symmetry when using the different methods. The 3D method does not suggest a low standard deviation, as do the linear measurements. This indicates that we need to reevaluate the relationship between lithic analysis method and cognition and warrants additional study of current lithic analytical methods.

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### References Cited:

- Chase, Philip G., and Harold L. Dibble. 1987. Middle Paleolithic symbolism: a review of current evidence and interpretations. *Journal of Anthropological Archaeology* 6.3: 263–296.
- Crompton, Shirley. 2007. 3D lithic analysis. *Proceedings 2007 Congress on Computer Applications in Archaeology*.
- Hodgson, Derek. 2009. Evolution of the visual cortex and the emergence of symmetry in the Acheulean techno-complex. *Comptes Rendus Palevol* 8.1: 93–97.
- Kerry, Kristopher W. and Donald O. Henry. 2000. Conceptual Domains, Competence, and Chaîne Opératoire in the Levantine Mousterian. In *The Archaeology of Jordan and Beyond*, Lawrence E. Stager, Joseph A. Greene, and Michael D. Coogan (eds.). Eisenbrauns, Winona Lake, Indiana.

## Paleoecological Evidence for Humid and Arboreal Environment at the Levantine Early UP and its Implication for Modern Human Dispersal from Africa: Micromammal Evidence from the Mugar el Hamamah, Ajlun District, Jordan

Miriam Belmaker, *Anthropology, The University of Tulsa, USA*  
 Jamie L. Clark, *Anthropology, University of Alaska, Fairbanks, USA*  
 Rosa Maria Albert, *Department of Prehistory, Ancient History and Archaeology, University of Barcelona, SPAIN*  
 Trina L. Arpin, *Archaeology, Boston University, USA*  
 Dan Cabanes, *Department of Prehistory, Ancient History and Archaeology, University of Barcelona, SPAIN*  
 Gideon Hartman, *Anthropology, University of Connecticut, USA*  
 Fuad Hourani, *Archaeology, University of Jordan, JORDAN*  
 Jason A. Rech, *Geology, University of Miami, USA*  
 John J. Shea, *Anthropology, Stony Brook University, USA*  
 Chantel E. White, *Anthropology, University of Notre Dame, USA*  
 Liv Nilsson Stutz, *Anthropology, Oxford College of Emory University, USA*  
 Aaron J. Stutz, *Anthropology, Oxford College of Emory University, USA*

The role of climate in the dispersal of modern humans from Africa between 50–30 ka is debated. Paleoclimatic data suggested that the Last Glacial was either cold/dry (Bar-Matthews et al. 2003), or cold/wet (Frumkin et al. 2011). Paleoecological data from the mesic Mediterranean region has supported the cold/wet interpretation (Belmaker and Hovers 2011). To date, there is little paleoecological evidence from Semi Arid and Arid regions in the Levant to refine our understanding of local paleoecology of the region. Here we provide the first evidence of paleoecology from the Eastern flanks of the Lisan Catchment area dated to ca. 40 ka based on micromammal assemblage retrieved from Mughr el-Hamamah (MHM), Jordan. Located on the eastern slopes of the Jordan Valley (Ajlun District), MHM exhibits *in situ* deposits dated to the Levantine EUP. The samples include micromammal fauna from squares B5 and C5. Sediments were dry screened with 2mm mesh. Micromammals were identified to species and a detailed taphonomic study conducted. Results suggested that the assemblage is highly dominated by the Syrian squirrel (*Sciurus anomalus*), typical of cool and humid climate. It is common in Late Glacial fauna of the Mediterranean of the Levant in sites such as Kebara UP and Amud. Today it is known only from high elevation in Turkey, Syria and Jordan. Other taxa include several genera of murids, further supporting woodland habitats. Taphonomic analysis indicates that the assemblage is consistent with a predatory origin. These results support analysis of Dead Sea speleothems indicating a high stand of Lake Lisan and an increase in humidity ca. 40 ka (Sorin et al. 2010). This study suggests that the Eastern flanks of the central Jordan Valley, a semi-arid region, supported an arboreal habitat during the EUP. This may have been a contributing factor for AMH dispersal into the region.

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### References Cited:

- Bar-Matthews, M., Ayalon, A., Gilmour, M., Matthews, A., and Hawkesworth, C. 2003. Sea-land oxygen isotopic relationships from planktonic foraminifera and speleothems in the Eastern Mediterranean region and their implication for paleorainfall during interglacial intervals. *Geochimica et Cosmochimica Acta* 66, 1–19.
- Belmaker, M. and Hovers, E. 2011. Ecological Change and the Extinction of the Levantine Neanderthals: Implications from a Diachronic Study of Micromammals from Amud Cave, Israel. *Quaternary Science Reviews* 30, 3196–3209.
- Frumkin, A., Bar-Yosef, O., and Schwarcz, H.P. 2011. Possible paleohydrologic and paleoclimatic effects on hominin migration and occupation of the Levantine Middle Paleolithic. *Journal of Human Evolution* 60, 437–451.
- Sorin, L., Anton, V., Bar-Matthews, M., Pinhasi, R., and Frumkin, R. 2010. Late Pleistocene palaeoclimatic and palaeoenvironmental reconstruction of the Dead Sea area (Israel), based on speleothems and cave stromatolites. *Quaternary Science Reviews* 29, 1201–1211.

## Unravelling the Functional Biomechanics of Dental Morphological Features

Stefano Benazzi, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Nhu Huynh Nguyen, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Ottmar Kullmer, *Department of Palaeoanthropology and Messel Research, Senckenberg Research Institute, GERMANY*  
 Jean-Jacques Hublin, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*

Most of the morphological features recognized in hominin teeth, particularly the topography of the occlusal surface, are generally interpreted as an evolutionary functional adaptation for food processing. In this respect, we can also expect that the general architecture of a tooth reflects a response to withstand the high stresses produced during masticatory loadings. Here we use an engineering approach, finite element method (FEM), with an advanced loading concept derived from individual occlusal wear information to evaluate whether some structural traits usually found in hominin and extant great ape molars, such as the trigonid crest, the entoconid-hypoconulid crest, and the protostylid, have important biomechanical functions. Three-dimensional digital models of the antagonist lower M2 and upper M1-M2 of three dried *Gorilla gorilla* skulls differing in wear stages were obtained from  $\mu$ CT scans to carry out a virtual kinematic analysis of the surface contacts during the power stroke in the Occlusal Fingerprint Analyser (OFA) software. Afterwards, FEM were applied in the lower M2s to analyse the pattern of stress distribution during maximum intercuspation, considering the occlusal contact patterns for individual loading scenarios. Our results show that in unworn and slightly worn lower M2s tensile stresses concentrate in the grooves of the occlusal surface. In such condition, the trigonid and the entoconid-hypoconulid crests act to reinforce the crown, interrupting the propagation of the stresses. Similarly, the protostylid is shaped like a buttress to suffer the high tensile stresses concentrated in the deep buccal groove. These dental traits are less useful in the worn lower M2, because tensile

stresses decrease physiologically in the crown due to the enlargement of contact areas. This suggests that the wear process might have a crucial influence in the evolution of teeth able to endure specific stresses and reduce tooth failure in specific periods of the lifetime.

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## Long-term Continuity in Middle Stone Age Lithic Technology from Niassa, Mozambique

Tim Bennett, *Archaeology, University of Calgary, CANADA*

Excavations conducted in 2007 at Mvumu, an open air site near the shore of Lake Niassa in northwestern Mozambique, have recovered a Middle Stone Age (MSA) lithic assemblage dated to 29 ka (Bennett 2011; Mercader et al. 2012). Techno-typological analysis of these artifacts has allowed for the detailed characterization of MSA lithic technology from the Mozambican side of the Niassa/Malawi basin (see Thompson et al. 2012 for comparable Malawian lithics). Defining characteristics of this assemblage include: 1) the nearly exclusive use of local milky quartz, 2) use of simple and prepared core reduction strategies that show little concern for raw material conservation; and, 3) an expedient tool industry with morphologically nonstandardized finished products. Despite the young chronology of this assemblage, it cannot be interpreted as a Late Stone Age (LSA) industry because of the large size of detached products, prominence of prepared core technology, and tool assemblage dominated by scrapers, awls, and points (Mercader et al. 2012; see also Diez-Martín et al. 2009). Bipolar reduction is rare and blade production is absent. The intentional truncation of flakes was commonly observed in the assemblage and represents an important feature of the primary awl production technique employed at Mvumu. The techno-typological pattern observed in these lithics is mirrored in assemblages from the nearby open air site Mikuyu (Mercader et al. 2008), highland cave site Ngalue located ~70km inland (Mercader et al. 2009), and numerous recorded surface scatters. Geochronometry conducted at Ngalue suggests that this lithic industry was being produced by at least 105 ka. These dates show a period of lithic technological continuity spanning at least 76,000 years. These data also show that distinct MSA lithic technology persisted in Niassa for ~30,000 years after the emergence of LSA technology in adjacent regions (e.g., Diez-Martín et al. 2009; Gliganic et al. 2012).

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### References Cited:

- Bennett, T. 2011. *Middle Stone Age Lithic Technology at Mvumu, Niassa, Mozambique*. M.A. Thesis, University of Calgary.
- Diez-Martín, F., Domínguez-Rodrigo, M., Sánchez, P., Mabulla, A., Tarrío, A., Barba, R., Prendergast, M., and de Luque, L. 2009. The Middle to Later Stone Age technological transition in East Africa. New data from Mumba Rockshelter Bed V (Tanzania) and their implications for the origin of modern human behavior. *Journal of African Archaeology* 7, 1–27.
- Gliganic, L.A., Jacobs, Z., Roberts, R.G., Domínguez-Rodrigo, M., and Mabulla, A.Z.P. 2012. New ages for Middle and Later Stone Age deposits at Mumba rockshelter, Tanzania: Optically stimulated luminescence dating of quartz and feldspar grains. *Journal of Human Evolution* 62, 533–547.
- Mercader, J., Asmerom, Y., Bennett, T., Raja, M., and Skinner, A. 2009. Initial excavation and dating of Ngalue Cave: a Middle Stone Age site along the Niassa Rift, Mozambique. *Journal of Human Evolution* 57, 63–74.
- Mercader, J., Bennett, T., and Raja, M. 2008. Middle Stone Age starch acquisition in the Niassa Rift, Mozambique. *Quaternary Research* 70, 283–300.
- Mercader, J., Gosse, J., Bennett, T., Hidy, A.J., and Rood, D.H. 2012. Cosmogenic nuclide age constraints on Middle Stone Age lithics from Niassa, Mozambique. *Quaternary Science Reviews* 47, 116–130.
- Thompson, J.C., Mackay, A., Wright, D.K., Welling, M., Greaves, A., Gomani-Chindebvu, E., and Simengwa, D. 2012. Renewed investigations into the Middle Stone Age of northern Malawi. *Quaternary International* 270, 129–139.

## Virtual reconstruction of the endocast of *Sahelanthropus tchadensis*

Thibaut Bienvenu, *Chaire de Paléontologie Humaine, Collège de France, FRANCE; and, iPHEP, Université de Poitiers, FRANCE; and, Department of Anthropology, University of California-San Diego, USA*

Dean Falk, *Department of Anthropology, Florida State University, USA; and, School for Advanced Research, USA*

Katerina Semendeferi, *Department of Anthropology, University of California-San Diego, USA; and, Neuroscience Graduate Program, University of California-San Diego, USA*

Franck Guy, *iPHEP, Université de Poitiers, FRANCE*

Christoph Zollikofer, *Anthropologisches Institut, Universität Zürich-Irchel, SWITZERLAND*

Marcia Ponce de León, *Anthropologisches Institut, Universität Zürich-Irchel, SWITZERLAND*

Paul Tafforeau, *European Synchrotron Radiation Facility, FRANCE*

Hassane Taisso Mackaye, *Département de Paléontologie, Université de N'Djamena, CHAD*

Andossa Likius, *Département de Paléontologie, Université de N'Djamena, CHAD*

Patrick Vignaud, *iPHEP, Université de Poitiers, FRANCE*

Michel Brunet, *Chaire de Paléontologie Humaine, Collège de France, FRANCE; and, iPHEP, Université de Poitiers, FRANCE*

Fossil remains assigned to the species *Sahelanthropus tchadensis* (Brunet et al. 2002) have been found by the Mission Paléoanthropologique Franco-Tchadienne (MPFT), in the Toros-Menalla fossiliferous area, Djurab Desert, Chad, 2,500km west from the East African Rift Valley. Continental sediments bearing the fossils have been dated to 7 Ma by both radiochronologic and biochronologic methods. The fossils display a number of derived cranial and dental characters, making *S. tchadensis* the earliest known hominid species (the term hominid is used here to denote humans and their bipedal ancestors; hominids are the sister group of panids, which include living common chimpanzees, bonobos, and their unknown fossil relatives). Inner casts of braincases, or endocasts, constitute the only direct way to infer brain morphology in fossil specimens. Among the collected specimens of *S. tchadensis*, the nearly complete holotype

cranium TM 266-01-060-1, of a male individual nicknamed Toumaï, has been virtually reconstructed to correct for postmortem distortion. Here we announce the virtual reconstruction of the endocast of Toumaï. The cranium is filled with highly mineralized matrix, and the inner table of cranial bone is fragmented and distorted. Thus, classical methods of endocast extraction could not be applied. We developed a special protocol, involving 3D X-ray synchrotron microtomography, semi-automated segmentation of the inner table, surface extraction, and correction of postmortem distortion based on both rigid and thin-plate spline transformations, to reconstruct the endocast of Toumaï. This endocast opens a unique window on the first steps of human brain evolution just after the split between humans and chimpanzees. The endocranial volume of TM 266-01-060-1 confirms data (360–370cc) already published for the 3D cranium reconstruction. It falls within the variability range of chimpanzees. The studies are still in progress, but numerous features such as the brainstem and occipital lobes already confirm the hominid status of *S. tchadensis*.

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#### References Cited:

Brunet, M., Guy, F., Pilbeam, D., Mackaye, H.T., Likius, A., Ahounta, D., Beauvilain, A., Blondel, C., Bocherens, H., Boisserie, J.-R., de Bonis, L., Coppens, Y., Dejax, J., Denys, C., Douring, P., Eisenmann, V., Fanone, G., Fronty, P., Geraads, D., Lehmann, T., Lihoreau, F., Louchart, A., Mahamat, A., Merceron, G., Mouchelin, G., Otero, O., Pelaez Campomanes, P., Ponce de León, M., Rage, J.-C., Sapanet, M., Schuster, M., Sudre, J., Tassy, P., Valentin, X., Vignaud, P., Viriot, L., Zazzo, A., and Zollikofer, C. 2002. A new hominid from the Upper Miocene of Chad, Central Africa. *Nature* 418: 145-151.

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## ESR Dating Herbivore Teeth and Snails at Dakhleh Oasis: Testing the Potential for Hominins in Egypt's Western Desert

Bonnie A.B. Blackwell, *Chemistry, Williams College, Williamstown, MA, 01267-2692, USA*  
 Anne R. Skinner, *Chemistry, Williams College, Williamstown, MA, 01267-2692, USA*  
 Ada Huang, *RFK Science Research Institute, Glenwood Landing, NY, 11547-0866, USA*  
 Kelly K.L. Chen, *RFK Science Research Institute, Glenwood Landing, NY, 11547-0866, USA*  
 Maxine R. Kleindienst, *Anthropology, University of Toronto at Mississauga, Mississauga, ON, L5L 1C6, CANADA*  
 Jennifer R. Smith, *Earth & Planetary Sciences, Washington University in St. Louis, St. Louis, MO, 63130-4862, USA*  
 J.I.B. Blickstein, *RFK Science Research Institute, Glenwood Landing, NY, 11547-0866, USA*  
 M.Q.D. Kim, *RFK Science Research Institute, Glenwood Landing, NY, 11547-0866, USA*  
 N.L. Wise, *Chemistry, Williams College, Williamstown MA, 01267, USA*  
 C.S. Churcher, *Zoology, University of Toronto, Toronto, ON, M5S 3B2, CANADA*

In Egypt's hyperarid Western Desert, people can only inhabit Dakhleh thanks to modern pumping technology. Yet Quaternary artesian spring deposits, buried soils, and lake sediment, such as the calcareous silty sediment (CSS), all demonstrate that surface water existed at Dakhleh Oasis during three or more Oxygen Isotope Stages (MIS). Artifacts ranging from Upper Acheulean and Middle Stone Age (MSA) to Roman and modern debris occur in the lags on the desert surface. Artifacts, fossil ungulate teeth and snails occur within the Pleistocene deposits and dot the surface. In the late Pleistocene, a paleolake >60km<sup>2</sup> in area existed, probably in a basin formed by the Dakhleh impact event. Its lake deposits may have reached >10m thick locally. At Bir Taleta, south of Deir el Hagar, tooth fragments and artifacts likely attributable to the Aterian and Middle Stone Age sit in blowouts. Masara sand and other Holocene deposits mainly form the surface, but Late Quaternary erosion exposed the underlying red Paleolake Kellis mud, the Mut Formation mud and silt, and even the Taref Formation sandstone. The erosion deflated heavier clasts, including teeth and lithic pieces, from these layers to create the surficial lag. Blowouts have also exposed Middle Pleistocene skeletal remains, including *Gazella*, *Phacochoerus*, *Loxodonta africana*, *Hippopotamus*, *Pelorovis antiquus*, *Syncerus*, *Felis lybica*, Late Pleistocene bovids, equids, and other ungulates. From Bir Taleta, more than 50 herbivore tooth fragments have been independently dated with ESR using modelled time-averaged cosmic and sedimentary dose rates. Their age distribution shows that herbivores lived in the area briefly in early MIS 3, and for extended periods in MIS 1, 5c-e, 6c, 7a, and 7c. During at least six periods during the later Quaternary, therefore, higher rainfall and/or groundwater tables made the Western Desert more habitable than today for herbivores, and thus, likely also for hominins.

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## Tephrostratigraphy and the Early Middle Stone Age in the Kapthurin Formation, Kenya: New Correlations, Dates, and Prospects for Future Research

Nick Blegen, *Anthropology, University of Connecticut, USA*  
 Sally McBrearty, *Anthropology, University of Connecticut, USA*

The Kapthurin Formation, Kenya, dated >545–235 ka by <sup>40</sup>Ar/<sup>39</sup>Ar on volcanic units, has produced abundant Middle Pleistocene fossil and archaeological material relevant to the origin of *Homo sapiens* (Deino and McBrearty 2002). Updated tephrostratigraphy of the Bedded Tuff Member (K4), Kapthurin Formation based on >2300 microprobe analyses of 205 tuffs shows: 1) characteristically MSA material dates between 235–284 ka; 2) a newly recognized tuff may provide dates as old as 380 ka for interstratified Acheulean and MSA material at the base of K4; and, 3) correlation of a tuff capping the Sibilo School Road Site (SSRS=GnJh-79) provides the first lithic and faunal assemblage bridging this gap. Correlations of tuffs capping the MSA sites of Koimilot (GnJh-74) and Keraswanin (GnJh-78) show these belong to the upper portion of K4 between 235–284 ka demonstrating diverse reduction methods, and production of Levallois points and bifacial obsidian points were present early in the MSA. Analysis has also revealed a previously unrecognized pumiceous tuff unit. The stratigraphic position and geochemical composition of this tuff suggests it is significantly older than 284±12 ka, the oldest directly dated unit in the Bedded Tuff Member (Tryon and McBrearty 2006). Comparison with units <sup>40</sup>Ar/<sup>39</sup>Ar dated by Dunkley et al. (1993) suggest this unit could be as old as 380 ka. This tuff overlies the majority of previously reported sites in the

formation, suggesting the age of the Acheulian to MSA transition in this part of East Africa may be backdated from 284 ka to 380 ka. Correlation of the tuff capping the SSRS shows it is a proximal facies of a tephra  $^{40}\text{Ar}/^{39}\text{Ar}$  dated to  $284\pm 12\text{ka}$  (Deino and McBrearty 2002). Collections at this site suggest MSA technology in association with faunal material. Planned excavation seeks to illustrate the nature of lithic and faunal material at this site.

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**References Cited:**

- Deino, A. and McBrearty, S. 2002.  $^{40}\text{Ar}/^{39}\text{Ar}$  Dating of the Kapthurin Formation, Baringo, Kenya. *Journal of Human Evolution* 42, 185–210.  
 Dunkley, P.N., Smith, M., Allen, D.J., and Darling, W.G. 1993. *The Geothermal Activity and Geology of the Northern Sector of the Kenya Rift Valley*. British Geological Survey International Series Research Report SC/93/1, Keyworth, Nottingham.  
 Tryon, C.A. and McBrearty, S. 2006. Tephrostratigraphy of the Bedded Tuff Member (Kapthurin Formation, Kenya) and the Nature of Archaeological Change in the Later Middle Pleistocene. *Quaternary Research* 65, 492–507.

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## Initial Upper Palaeolithic to Epi-Paleolithic Marine Mollusc Exploitation at Ksâr' Akil (Lebanon): New Zooarchaeological, Radiometric, and Isotopic Data

Marjolein Bosch, *Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, GERMANY*  
 Marcello Mannino, *Human evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, GERMANY*  
 Amy Predergast, *Division of Archaeology, University of Cambridge, Cambridge, UNITED KINGDOM*  
 Tamsin O'Connell, *Division of Archaeology, University of Cambridge, Cambridge, UNITED KINGDOM*  
 Frank Wesselingh, *Geology, National Natural History Museum Naturalis, Leiden, THE NETHERLANDS*  
 Johannes van der Plicht, *Center for Isotope Research, Groningen University, Groningen, THE NETHERLANDS*  
 Jean-Jacques Hublin, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, GERMANY*

Marine molluscs are a potential source of data on past environments, human subsistence practices, and seasonality of site occupation. Here we present new data arising from the study of the shell assemblage from Ksâr' Akil (Lebanon), a key archaeological site with a 23m long sequence. Shells of marine molluscs start to occur in the Initial Upper Paleolithic at  $>40$  kyr uncal BP. Our zooarchaeological study of the assemblage shows that at Ksâr' Akil shells of marine molluscs were used as tools (i.e., *Glycymeris* sp.), ornaments (e.g., *Nassarius gibbosulus* and *Columbella rustica*), and as a source of food (e.g., *Osilinus turbinatus*, *Patella rustica*, and *Patella caerulea*). Here we focus on the taxa exploited for dietary purposes, which taphonomically differ from the rest of the assemblage. While most shells were collected empty either in active beach environments or from fossil deposits, 'food species' were collected live from intertidal rocky shores. Anthropogenic origin of the assemblage is evident from the frequent intentional removal of the apices of *O. turbinatus* (to facilitate extraction) and occasional burning. Furthermore, we undertook AMS radiocarbon dating to refine the chronology of the site and oxygen isotope analysis on *O. turbinatus* shells, both for environmental reconstructions and determination of seasonality of shellfish exploitation). The radiocarbon dates show that marine molluscs were exploited throughout the occupation of Ksâr' Akil by anatomically modern humans, from around 40.5 kyr uncal BP until at least 26.2 kyr uncal BP. The preliminary results of the isotope analyses suggest that during most occupational phases, shellfish exploitation was practiced in every season, albeit with an emphasis on winter/spring. Our investigations indicate that although marine molluscs represented a minor source of protein, they contributed essential nutrients not readily available in the terrestrial foods that constituted the bulk of the diet of the occupants of Ksâr' Akil.

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## Archaeological Investigations at Elandsfontein, South-West Coast South Africa

David R. Braun, *Anthropology Department, George Washington University, USA*  
 Naomi E. Levin, *Earth and Planetary Sciences, Johns Hopkins University, USA*  
 Deano Stynder, *Department of Archaeology, University of Cape Town, SOUTH AFRICA*  
 Will Archer, *Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Darya Presnyakova, *Anthropology Department, Rutgers University, USA*  
 David Roberts, *Council for Geoscience, SOUTH AFRICA*  
 Frances Forrester, *Department of Anthropology, NYCEP, USA*  
 Andrew I. Herries, *Archaeology Program, La Trobe University, AUSTRALIA*  
 Kathryn Fitzsimmons, *Human Evolution Department, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Thalassa Mathews, *Natural History, Iziko Museums of South Africa, SOUTH AFRICA*  
 Laura C. Bishop, *Research Centre for Evolutionary Anthropology and Palaeoecology, Liverpool John Moores University, UNITED KINGDOM*  
 Robyn Pickering, *School of Earth Sciences, University of Melbourne, AUSTRALIA*

Characteristically human cognitive and social features likely developed in Africa during the Late Pleistocene. The dramatic climatic oscillations of the Middle to Late Pleistocene may be key to understanding these particular adaptations. This variability would have intensified selective pressures on behavioral versatility and may have played a role in developing culturally mediated adaptations to diverse situations. Information on the temporal and spatial appearance of these novel behaviors is increasing, yet little is known about the roots of such adaptations in populations that preceded modern humans. This severely limits the ability to understand the evolutionary significance of these singularly human behaviors. Here we present new data from excavations and landscape scale investigations of the Middle Pleistocene deposits at the archaeological site of Elandsfontein, Western Cape, South Africa. Although this site has a long history of research, systematic investigations of the geological and paleoecological context of this site require further clarification. We present the first comprehensive stratigraphic and paleogeographic framework of the multiple archaeological localities

within the extensive open air Middle Pleistocene deposits at Elandsfontein. Allied with new geochronological data, these developments provide novel insights into the complexities represented by the multiple fossiliferous horizons at Elandsfontein. These data enable a detailed analysis of hominin behavior relative to the heterogeneous environments of the West Coast of South Africa. New excavations at Elandsfontein document behavioral links among spatially associated artifacts and fossils. Geoarchaeological data provide information on the complex post-depositional history of these archaeological assemblages. Data from the associated lithic assemblages indicate that hominins employed a diverse array of technological strategies, which appear to be mediated by paleoecological context, resource availability, and material properties of these tools.

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## Evaluating Prime-Dominated Prey Mortality Profiles at Pleistocene African Archaeological Sites

Henry Bunn, *Anthropology, University of Wisconsin-Madison, USA*

Alia Gurtov, *Anthropology, University of Wisconsin-Madison, USA*

The prime-adult-dominated mortality profile of large bovids in the 1.8 Ma FLK Zinj assemblage, Olduvai Gorge, Tanzania, was recently attributed to ambush hunting by early *Homo* (Bunn and Pickering 2010). We now investigate a logical follow-up question: Is enough known about the causes and pervasiveness of prime-adult-dominated mortality profiles (defined as >70% prime adults) from modern ecosystems and from archaeological sites to warrant their attribution solely to hominin hunting? Besides hominin hunting, three methods of scavenging could have provided the large bovids butchered at FLK Zinj: first-access scavenging from non-predator-related accidents; late-access passive scavenging from lion (or other) kills; and, early-access aggressive scavenging from lion (or other) kills. We present new data on hunted prey from Hadza bowhunting (e.g., N=50 impala, among others) near Lake Eyasi, Tanzania, and from San bowhunting in the Kalahari Desert, Botswana, documenting non-selective, living-structure profiles. We present new data on drowned wildebeest (N=175) from Lake Masek, in the Serengeti, documenting many prime adults but also a significantly high percentage of old adults, unlike the profile at FLK Zinj. We also examine mortality profiles from modern African carnivores and from Old World Pleistocene archaeological sites, revealing that while prime-dominated profiles are present in some archaeological assemblages, particularly some Late Pleistocene European sites involving cervids, they are not documented from lion or other larger carnivore predation. Moreover, living-structure profiles with prime adults representing ~ 50–60% of prey are common, particularly in African archaeological assemblages involving bovids hunted by humans. Although taphonomic bias, prey socioecology, and season of death may all influence mortality profiles, prime-dominated profiles require careful evaluation. The prime-dominated profile at FLK Zinj is significantly different from profiles formed by the three scavenging methods, which likely indicates hunting by *Homo*.

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### References Cited:

Bunn, H.T. and Pickering, T.R. 2010. Bovid mortality profiles in paleoecological context falsify hypotheses of endurance running hunting and passive scavenging by early Pleistocene hominins. *Quaternary Research* 74, 395–404.

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## Spatial Organization Within Open Air Middle Paleolithic Sites in France

Amy Clark, *School of Anthropology, University of Arizona, USA*

The spatial positioning of artifacts within sites can be used to identify activities performed at the site, how these activities were organized in space, how various artifact types moved around the site, and even to address more elusive questions concerning group size and number of occupations. However, studies of spatial organization are often limited by the extent of excavation and the geological context (particularly in the case of caves and rockshelters). This study uses data from open air French Middle Paleolithic sites excavated by INRAP (Institut national de recherches archéologiques préventives) which were excavated on large spatial scales (up to 1,200 square meters) and are, for the most part, from minimally compromised geologic contexts. The sites included in this study range from La Doline de Cantalouette II, a raw material workshop, to La Folie, a short term camp site. This study utilizes both spatial patterning of lithic debitage and refitting of knapping events to analyze spatial organization within sites and variation in spatial organization between sites. By studying the distribution of artifact types throughout the site, we can gain insight into how different categories of artifact were treated. Many intra-site patterns of artifact movement mimic what we see on the large scale (i.e., tools are more mobile than core reduction debris) but there are some interesting differences. The treatment of these artifacts at a range of sites can speak not only to the use of the lithics themselves, but the use of the site and the intensity of its occupation.

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## Results from a Taphonomic Study of the Final Middle Stone Age Occupation at Sibudu Cave, South Africa

Benjamin Collins, *Anthropology, McGill University, CANADA*

Sibudu Cave has provided detailed information on Middle Stone Age culture, especially from the post-Howiesons Poort (approximately 58,000 years ago) and earlier occupations. The final Middle Stone Age occupation (approximately 38,000 years ago), has not featured as prominently in previous research, but provides an important opportunity to examine the Middle-to-Later Stone Age transition. This poster contributes to understanding Sibudu's final Middle Stone Age occupation by reporting on the results from a detailed taphonomic study, which assessed bone surface modifications (including cut marks, percussion marks, carnivore tooth marks, rodent gnawing marks, and trampling marks), limb shaft circumference ratios, fracture patterning, burning, fragmentation, and skeletal element abundances. These measures demonstrate a strong anthropogenic origin for the faunal assemblage, with human-affected bone surface modifications being much more frequent than carnivore tooth marks and few carnivore remains being present. The assemblage resembles those from earlier Middle Stone Age occupations from Sibudu, as it is highly fragmentary and the majority of the bone is burned. Furthermore, the taphonomic data, when contextualized with the geoarchaeological data, suggest that used bone was burned and discarded during regular site maintenance. This conclusion is consistent with those from earlier Middle Stone Age occupations from Sibudu and demonstrated continuity in behavior and site organization through time.

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## First Late Pleistocene Fossil Fauna From the Dry Coastal Zone of Tropical Southwestern Asia: Implications for Early Human Dispersals Along Innundated Coastal Corridors

August G. Costa, *Anthropology, Indiana University, USA*

A diverse Late Pleistocene fossil assemblage was recovered from a sea cliff near Gopnath point in Gujarat, northwestern India. These remains are the first large sample of Pleistocene faunal materials from arid northwestern India and the larger Nubo-Sindian zone south of the 27th parallel. Several taxa known mainly from reworked alluvial deposits of peninsular India are documented for the first time from an undisturbed open-air site adjoining the Great Indian Desert. Remains, from an undescribed reduncine, were identified that constitute the only record of this group from the Middle to Late Pleistocene outside of Africa. The context, composition, and type of fossil preservation reported here is without precedent in South Asia. The site formed in an interdunal pond within a carbonate dune field that was part of a larger coastal oasis ecosystem that existed in the Cambay Gulf during hyper-arid glacial lowstands. The Gopnath fossils are correlated to Late Acheulean lithics from a coastal cliff locality (<8km) at Madhuban. These finds provide the first vertebrate evidence of glacial lowstands and their influence on Late Pleistocene paleobiogeography within the dynamic dry coastal corridor linking India to Africa. They offer a rare glimpse of a lost landscape and an obscure fossil community which are critical to understanding the historical biogeography of the hinterland along the Arabian seashore as well as validating models of early human dispersal out of Africa.

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## Middle Paleolithic and Neolithic Occupations on the Mundafan Lakeshore, Empty Quarter, Saudi Arabia: Implications for Climate Change and Human Dispersals

Remy Crassard, *UMR 5133 Archeorient, CNRS, FRANCE*

Michael D. Petraglia, *School of Archaeology, Research Laboratory for Archaeology and the History of Art, University of Oxford, UNITED KINGDOM*

Nick Drake, *Department of Geography, King's College London, UNITED KINGDOM*

Bernard Gratuze, *UMR 5060 Iramat, CNRS, FRANCE*

Abdullah Alsharekh, *Department of Archaeology, King Saud University, SAUDI ARABIA*

The Arabian Peninsula is a key region for understanding climate change and human occupation history in a marginal environment. The Mundafan paleolake is situated in the Empty Quarter of Saudi Arabia. Here we report the first discoveries of Middle Paleolithic and Neolithic archaeological sites in association with the paleolake. We associate the human occupations with new geochronological data, and suggest the archaeological sites date to the wet periods of Marine Isotope Stage 5 and the Early Holocene. The archaeological sites indicate that humans repeatedly penetrated the ameliorated, but somewhat marginal, environments of the Empty Quarter. The

sites are probably short term occupations, with the Neolithic sites focused on hunting as indicated by points and weaponry. Middle Paleolithic assemblages at Mundafan support a lacustrine adaptive focus in Arabia. Provenancing of obsidian artifacts indicates that Neolithic groups at Mundafan had a wide wandering range, with transport of artifacts from distant sources.

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## A New Osteological Approach to Inferring Hominin Social Behavior: Seeking Facial Indicators of Testosterone Level

Jessamy Doman, *Anthropology, Yale University, USA*  
 Andrew Hill, *Anthropology, Yale University, USA*  
 Richard Bribiescas, *Anthropology, Yale University, USA*

A new method of inferring androgen levels, and thus mating behavior, in fossil species is here described. We review evidence of cranial dimensions affected by testosterone (T) level in humans (Verdonck et al. 1999) and investigate whether those landmarks are similarly T-sensitive in non-human primates, and thus fossil humans. The results indicate that certain mandibular and anterior-facial measurements closely mirror androgen profiles in ape species. This relationship is strongest in the great apes, proving that it is phylogenetically deep enough to predict T levels in fossil hominins. Baseline androgen levels in primate species, as well as dimorphism between the sexes within species, are highly predictive of social systems (e.g., Sannen et al. 2003). In particular, it has been observed that increased T accompanies heightened intergroup aggression. Androgen levels vary greatly between the sexes in chimpanzees, whereas the difference is insignificant in bonobos (Gibb 1996). The low variation in T between bonobo males and females is interpreted to reflect decreased aggression and sexual competition in that species compared to chimpanzees. A number of facial measurements are found to be significantly different between male and female chimpanzees while bonobos demonstrate a much lower degree of sexual dimorphism, further supporting the use of craniofacial landmarks as predictors of T. Mandibular body measurements from hominin casts suggest high levels of male-male competition and by inference highly promiscuous mating systems in *Australopithecus afarensis* and *Homo erectus*. Early *H. sapiens* and *H. neanderthalensis* are also interpreted to have been subject to slightly elevated levels of male-male competition and thus a higher incidence of polygyny compared to modern humans. We present a method of obtaining a direct insight into the T levels of any single individual, rather than relying on large sample sizes to understand sexual dimorphism and, by proxy, mating systems of extinct species.

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### References Cited:

- Gibb, A. L. 1996. Dimorphism, Aggression and Sex: Urinary Androgens in Common Chimpanzees. Unpublished dissertation. Boston: Harvard University.  
 Sannen, A., Heistermann, M., Elsacker, L.V., Möhle, U., and Eens, M. 2003. Urinary testosterone metabolite levels in bonobos: A comparison with chimpanzees in relation to social system. *Behaviour* 140, 683–696.  
 Verdonck, A., Gaethofs, M., Carels, C., and de Zegher, F. 1999. Effect of low-dose testosterone treatment on craniofacial growth in boys with delayed puberty. *European Journal of Orthodontics* 21, 137–143.

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## Assessing the Paleoenvironmental Potential of Tufa Deposits from Taung and Sites of the Ghaap Plateau Escarpment, South Africa

Taylor Louise Doran, *Institute of Archaeology, University College London, UNITED KINGDOM*  
 Andy I.R. Herries, *Australian Archaeomagnetism Laboratory, La Trobe University, AUSTRALIA*  
 Philip Hopley, *Department of Earth Sciences, University College London, UNITED KINGDOM*

The tufa formations of the Ghaap Plateau escarpment provide a rich geological archive of human evolution in South Africa. This study examines the sedimentary and geochemical records of Ghaap tufa deposits to assess the potential of these sediments for providing reliable high-resolution paleoenvironmental information. X-ray diffraction, thin section examination, and stable isotope analysis were carried out on modern and ancient tufa carbonates collected from the Taung Child find site at Buxton-Norlim Limeworks, and from Malony's Kloof and Groot Kloof in the Ulco region. The results distinguish three distinct groups on the basis of their carbon and oxygen isotope composition, reflecting distinct depositional paleoenvironmental conditions. Consistent with proxy data from contemporaneous speleothems at hominin-bearing caves in northern South Africa, the Plio-Pleistocene are characterized by light carbon and oxygen isotopes, while the younger deposits have increasingly heavier values. In particular, analysis of the Dart Deposits associated with the Taung Child (*Australopithecus africanus*) provides evidence effective for reconstructing the depositional and chronological context. The results of the present study demonstrate the value of the Ghaap Plateau escarpment tufa deposits, particularly in continental in semi-arid regions, which contain relatively few geological proxies (Cremaschi et al. 2010; Smith et al. 2004; Viles et al. 2007), and their potential for understanding the course of hominin evolution in South Africa.

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### References Cited:

- Smith, J., Giegengack, R., and Schwarcz, H. 2004. Constraints on Pleistocene pluvial climates through stable-isotope analysis of fossil-spring tufas and associated gastropods, Kharga Oasis, Egypt. *Palaogeography, Palaeoclimatology, Palaeoecology* 206, 157–175.  
 Cremaschi, M., Zerboni, A., Christoph Spötl, C., and Felletti, F. 2010. The calcareous tufa in the Tadrart Acacus Mt. (SW Fezzan, Libya) An early Holocene palaeoclimate archive in the central Sahara. *Palaogeography, Palaeoclimatology, Palaeoecology* 287, 81–94.  
 Viles, H. A., Taylor, M. P., Nicoll, K., and Neumann, S. 2007. Facies evidence of hydroclimatic regime shifts in tufa depositional sequences from the arid Naukluft Mountains, Namibia. *Sedimentary Geology* 195, 39–53.
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## Paleontology of the Mursi Formation, Lower Omo Valley, Ethiopia

Michelle S.M. Drapeau, *Anthropologie, Université de Montréal, CANADA*

René Bobe, *Anthropology, The George Washington University, USA*

Jonathan G. Wynn, *Geology, University of South Florida, USA*

Christopher J. Campisano, *School of Human Evolution and Social Change, Arizona State University, Institute of Human Origins, USA*

The Mursi Formation is the oldest formation of the Pliocene- Pleistocene Omo Group and is dated to more than 4 Ma. The sedimentary sequence is exposed along a strip ~35km by 4km, but it has received relatively little attention due to the difficult access to this area. Expeditions to the Lower Omo Valley between 1968 and 1973 focused on the Usno and Shungura Formations, but resulted in a faunal collection from the Mursi Formation of about 250 specimens coming exclusively from the Yellow Sands locality at the southern extent of the exposures. In 2009, we reinitiated an investigation of the formation, focusing on the northern tip of the formation, which confirmed that the sediments are fossiliferous and depositional environments are similar throughout. The faunal assemblage presents interesting characteristics. It is unusual in its large proportion of suids (42% of the mammalian fauna) and very small proportion of bovids (11%). The sample is also unusual in the relatively high frequency of deinotheres (7.3%) and the absence of primates. Taxon-specific carbon stable isotope values of the Mursi mammals (n=69) show more prevalence of C<sub>3</sub> diets than in other African Pliocene sites (Lothagam and Kanapoi, Kenya; Gona and Aramis, Ethiopia; Laetoli, Tanzania; Kollé, Chad), which suggests that the Mursi environments were more closed than those of these other sites. If this is so, the absence of primates in the formation is intriguing and may be due to the small samples retrieved thus far. Further work will help resolve this issue. Given the rather closed environments inferred for the Mursi, continued work in the area will yield valuable information regarding environmental variation at that time period and its relation to hominin occupation.

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## Is There a Second Species at Sterkfontein Member 4? Quantitative Approaches Using Second Maxillary Molars

Cinzia Fornai, *Department of Anthropology, University of Vienna, AUSTRIA*

Fred L. Bookstein, *Department of Anthropology, University of Vienna, AUSTRIA; and, Department of Statistics, University of Washington, USA*

Gerhard W. Weber, *Department of Anthropology, University of Vienna, AUSTRIA*

Clarke (e.g., 2008) has claimed that the *Australopithecus* fossil record at Sterkfontein Member 4 and Makapansgat represents two distinct species: *A. africanus* and the more *Paranthropus*-like *A. prometheus*. He bases this classification on craniofacial and dental traits, but this issue has not been resolved morphometrically. We assessed the morphological variability of the *Australopithecus* fossil record at Sterkfontein Member 4, examining the second maxillary molars (M<sup>2</sup>s: less worn than M<sup>1</sup>s and less variable than M<sup>3</sup>s). We considered 47 teeth, 30 from South African *Australopithecus*, *Paranthropus*, and early *Homo*, and the rest from European Neanderthals and recent modern humans. Micro-CT scans of the teeth were obtained and virtually segmented to extract 3D models for data collection. We used two different geometric morphometric approaches. A landmark based analysis of 3D landmarks and semilandmarks on the occlusal ridge curves for both the outer enamel surface (OES) and the enamel dentine junction (EDJ), and the analysis of cervical and crown outlines. In principal component plots, the landmark-based and crown outline analyses cluster *Homo* separately from australopithecines and distinguish Neanderthals from modern humans well. The corresponding thin-plate spline grids show that much of the discrimination owes to relative proportions of trigon and talon, and to the relative heights of cusps. The cervical outlines are not as informative as other features. Within the *Australopithecus* group are two distinct molar shape clusters based on the OES and EDJ. However, the correspondence with Clarke's species attribution (1988, 2008, personal communication) is imperfect, since Sts 52, which Clarke and other scholars confidently attribute to *A. africanus*, clustered with *A. prometheus*. The EDJ seemed to provide a clearer separation between groups, but only 3 EDJs for *A. africanus* were available. In accordance with Clarke's observations, *Paranthropus* and *A. prometheus* widely overlap in shape, but separate from *A. africanus* (except Sts 52!).

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### References Cited:

- Clarke, R.J. 1988. A new *Australopithecus* cranium from Sterkfontein and its bearing on the ancestry of *Paranthropus*. In: Grine F.E. (ed.), *Evolutionary History of the "Robust" Australopithecines*. Aldine de Gruyter, New York, pp. 285–292.
- Clarke, R.J. 2008. Latest information on Sterkfontein's *Australopithecus* skeleton and a new look at *Australopithecus*. *South African Journal of Science* 104, 443–449.

## Buia (UA 31) and the Parietal Expansion in *Homo*

Martin Friess, *Hommes, natures, sociétés, Muséum national d'Histoire naturelle, FRANCE*

Luca Bondioli, *Sezione di Antropologia, Museo Nazionale Preistorico Etnografico "L. Pigorini", ITALY*

Afredo Coppa, *Dipartimento di Biologia Ambientale, Università "La Sapienza", ITALY*

David Frayer, *Department of Anthropology, University of Kansas, USA*

Yosief Libsekal, *National Museum of Eritrea, ERITREA*

Tsegai Medin, *Institut Catala de Paleocologia Humana i Evolució Social, Universitat Rovira i Virgili, SPAIN*

Lorenzo Rook, *Dipartimento di Scienze della Terra, Università di Firenze, ITALY*

Roberto Macchiarelli, *Département Géosciences, Université de Poitiers, FRANCE*

Increased encephalization in *Homo* is associated with a trend toward cranial globularity, a key characteristic of *H. sapiens*, one of the contributing factors is the expansion of the parietal bones. While there is general agreement on this feature in Late Pleistocene humans, its occurrence and variability in Early and Middle Pleistocene hominins is subject to debate. The 1 Ma old cranium UA 31 from Buia, Eritrea, falls into a critical chronological gap between African and most Asian *H. erectus* specimens, and its preservation provides an opportunity to further examine the evolution of parietal shape dynamics. We present a GMM study of UA 31's parietal architecture, considered within the framework of a representative sample of fossil *Homo* (n=48). Comparative analyses also included a sample of 100 geographically diverse recent humans. 3D landmarks and semilandmarks were obtained from surface scans of original specimens and casts. Multivariate statistics were used to explore the variation of parietal size, shape, and evolutionary allometry. The results confirm that parietal shape reflects increased encephalization in *Homo* and, thus, that it can be used for phylogenetic assessments of hominin parietals. UA 31, despite its chronological position, bears some shape affinities with the more derived condition of later Pleistocene hominins, and appears to be distinct from earlier African and most Asian *H. erectus*. This is mostly due to its vertical expansion, as opposed to the low, flat shape of earlier human crania. However, even if its position within the common allometric trend supports the idea that its parietal shape is more derived than its size would suggest, nonetheless UA 31 falls within the size range of *H. erectus* sensu lato. While this may hint at an early onset of cranial reorganization in *Homo*, it may also reflect intraspecific variation at a chronological point still poorly represented in the fossil record.

## Dispersals Out of Africa and Back to Africa: Modern Origins in North Africa

Elena Garcea, *Department of Letters and Philosophy, University of Cassino and Southern Latium, ITALY*

The Out-of-Africa dispersal of early modern humans from northeastern Africa can be split into two major spells, an earlier one between about 130,000 and 80,000 years ago, and a later one after ca. 50,000 years ago. These two events are not only chronologically distinct, but underwent different environmental conditions and displayed different technological solutions, which alternately affected the Out-of-Africa movement. Given their substantial differences, I have suggested to name the former 'Out of Africa 2a' and the latter 'Out of Africa 2b' (Garcea 2010a, 2012). While modern humans in the Out-of-Africa 2a only reached the southern Levant, their Out-of-Africa-2b successors spread into Europe and the Middle East and eventually replaced the local previous inhabitants, Neandertals (Garcea 2010b; Shea 2010). Various explanations for the interruption of the early spell and for the success of the later one are suggested. The African modern humans who moved outside their continent were exposed to intensified interspecific competition with the indigenous Levantine Neandertal groups for the same ecological niche (Shea 2007). On the other hand, comparisons of DNA sequences between Neandertals and present-day humans support interbreeding in the late Pleistocene (Sankararaman 2012). Whether an unrivaled interspecific competition was a compelling reason, or it was simply due to individual or social choices, the early African modern humans who first moved out of Africa seem to have also participated in a Back to Africa movement (Henn et al. 2012). In fact, single nucleotide polymorphism (SNP) genotyping array data have shown that North African populations share more genomic ancestry with Near Eastern populations than with sub-Saharan African and European ones (Henn et al. 2012). The genetic sign of Neandertal admixture in North African humans (Sanchez-Quinto et al. 2012) has further corroborated a Back to Africa movement. The succession between Out- and Back-to-Africa movements is discussed.

### References Cited:

- Garcea, E.A.A. 2010a. Bridging the gap between in and out of Africa. In *South-Eastern Mediterranean Peoples Between 130,000 and 10,000 Years Ago*, E.A.A. Garcea (ed.), pp. 126–143. Oxbow Books, Oxford.
- Garcea, E.A.A. 2010b. The spread of Aterian peoples in North Africa. In *South-Eastern Mediterranean Peoples Between 130,000 and 10,000 Years Ago*, E.A.A. Garcea (ed.), pp. 37–53. Oxbow Books, Oxford.
- Garcea, E.A.A. 2012. Successes and failures of the human dispersals from North Africa. *Quaternary International* 270: 119–128.
- Henn, B.M., Botigué, L.R., Gravel, S., Wang, W., Brisbin, A., Byrnes, J.K., Fadhlaoui-Zid, K., Zalloua, P.A., Moreno-Estrada, A., Bertranpetit, J., Bustamante, C.D., and Comas, D. 2012. Genomic ancestry of North Africans supports back-to-Africa migrations. *PLoS Genetics* 8(1): e1002397. doi:10.1371/journal.pgen.1002397
- Sánchez-Quinto, F., Botigué, L.R., Civit, S., Arenas, C., Ávila-Arcos, M.C., Bustamante, C.D., Comas, D., and Lalueza-Fox, C. 2012. North African populations carry the signature of admixture with Neandertals. *PLoS ONE* 7(10): e47765. doi:10.1371/journal.pone.0047765
- Sankararaman, S., Patterson, N., Li, H., Pääbo, S., and Reich, D. 2012. The date of interbreeding between Neandertals and modern humans. *arXiv*: 1208.2238v1
- Shea, J.J. 2007. Behavioral differences between Middle and Upper Paleolithic *Homo sapiens* in the East Mediterranean Levant: the roles of intraspecific competition and dispersal from Africa. *Journal of Anthropological Research* 64, 449–488.
- Shea, J.J. 2010. Neandertals and Early *Homo sapiens* in the Levant. In *South-Eastern Mediterranean Peoples Between 130,000 and 10,000 Years Ago*, E.A.A. Garcea (ed.), pp. 126–143. Oxbow Books, Oxford.

## Testing the Color Vision Priority Hypothesis in Primates: Acquisition of Trichromatic Vision Affects the Vomeronasal System and not the Main Olfactory System

Eva Garrett, *Anthropology, The Graduate Center, CUNY, USA; and, New York Consortium in Evolutionary Primatology, USA*

Michael Steiper, *Anthropology, The Graduate Center, CUNY, USA; and, New York Consortium in Evolutionary Primatology, USA; and, Department of Anthropology, Hunter College of CUNY; and, Program in Biology, The Graduate Center, CUNY, USA*

The color vision priority hypothesis (Matsui et al. 2010; Nei et al. 2008) states that evolution of routine trichromacy in some primates lead to an overall reduction in olfaction. Multiple studies tested this hypothesis using data on olfactory gene families and produced conflicting results (Gilad et al. 2004; Liman and Innan 2003; Liman 2006; Matsui et al. 2010). These previous studies, however, did not clearly consider whether the main olfactory system (MOS) or vomeronasal system (VNS) are under different selection regimes and affected independently by trichromatic vision. Garrett and Steiper (unpublished) found that across mammals, size adjusted vomeronasal organ (VNO) length and VNO complexity predict proportion of functional vomeronasal receptor genes, and absolute ethmoid area predicts total number of olfactory receptor genes. Here we test whether VNS and MOS are independently affected by the acquisition of trichromacy in primates by performing pair-wise phylogenetically corrected generalized least squares comparisons on VNO length, size adjusted vomeronasal groove (VNG) length (an osteological proxy for the VNO), VNO complexity, ethmoid area, and color vision categories in 43 primate species. We find a significant negative correlation between color vision and multiple vomeronasal system variables. Ethmoid area was not related to color vision. We reject a general trade-off model between olfaction and trichromatic vision, and support a model in which only the VNS is affected. The MOS detects odorants and pheromones, where the VNS only detects the latter, so it is possible that increased energy demands of trichromatic vision relaxed selection on the VNS, while maintaining the MOS. We predict that VNS reduction will be detectable by observing VNG variation in fossil anthropoids, and future research will focus on testing evolutionary trade-off hypotheses using the fossil record.

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### References Cited:

- Gilad Y, Wiebe V, Przeworski M, Lancet D, and Pääbo S. 2004. Loss of olfactory receptor genes coincides with the acquisition of full trichromatic vision in primates. *PLoS biology* 2: E5.
- Liman E.R. 2006. Use it or lose it: molecular evolution of sensory signaling in primates. *Pflugers Archiv* 453(2): 125–131.
- Liman E.R. and Innan, H. 2003. Relaxed selective pressure on an essential component of pheromone transduction in primate evolution. *Proceedings of the National Academy of Sciences USA* 100: 3328–3332.
- Matsui, A., Go, Y., and Niimura, Y. 2010. Degeneration of olfactory receptor gene repertoires in primates: no direct link to full trichromatic vision. *Molecular Biology and Evolution* 27: 1192–1200.
- Nei, M., Niimura, Y., and Nozawa, M. 2008. The evolution of animal chemosensory receptor gene repertoires: roles of chance and necessity. *Nature Reviews Genetics* 9: 951–963.

## Foramen Magnum Position in Quadrupedal Catarrhines: Implications for Early Hominins

Christopher Gilbert, *Department of Anthropology, Hunter College of the City University of New York, USA*

Kris Kovarovic, *Department of Anthropology, Durham University, UNITED KINGDOM*

Ryan Poland, *Department of Anthropology, Durham University, UNITED KINGDOM*

The position of the foramen magnum and its inferred relationship to locomotor and postural behavior has played an important role in the study of early hominin evolution. Most often, studies have focused on the relatively posterior position of the foramen magnum in suspensory/knuckle-walking great apes and the relatively anterior position of the foramen magnum in bipedal hominin taxa. Recently, however, early hominins have been argued to be derived from a more generalized arboreal quadruped, as evidenced by the recent descriptions of the *Ardipithecus* postcranial material. Thus, if extant African apes are not appropriate models for the primitive condition seen in the earliest hominins, we must expand our sample to include more generalized quadrupedal catarrhines. Since none of the well-known Miocene ape taxa such as *Proconsul* preserve intact basicrania, extant cercopitheoid monkeys are the most appropriate available study group. This study examines foramen magnum position in papionin monkeys in an attempt to better understand foramen magnum position in quadrupedal catarrhines. The distance from basion to the bicarotid chord was calculated for 196 papionin basicrania and compared to published data for early hominin and great ape species. Results demonstrate that relative foramen magnum position is negatively allometric across papionin taxa such that larger taxa have a relatively smaller distance from basion to bicarotid. When plotted relative to hominin, great ape, and papionin species means, *Ardipithecus* is notable in the anterior position of its foramen magnum, but it falls within the total range of variation seen among individual papionin values. Therefore, it is possible that the anterior position of the foramen magnum in the earliest hominins is within the range of expected variation for a generalized quadruped of that size. Further research on generalized catarrhines is necessary to place the earliest hominins in a more comprehensive comparative framework.

## From Paleoneurology to Neuroanatomy: Insights on Hominin Brain Evolution Through Comparative Analysis of Cerebral Morphology in Humans and Chimpanzees

Aida Gómez-Robles, *Department of Anthropology, The George Washington University, USA*  
 William D. Hopkins, *Neuroscience Institute, Georgia State University, USA*  
 Chet C. Sherwood, *Department of Anthropology, The George Washington University, USA*

The study of hominin brain evolution relies mostly on evaluation of the endocranial morphology of fossil skulls (Holloway et al. 2004). However, only some general features of brain morphology are evident from endocasts and specific anatomical details can often be difficult or impossible to evaluate. We use geometric morphometric techniques to evaluate inter- and intraspecific differences in cerebral morphology in a sample of 72 chimpanzee and 73 human *in vivo* MRI scans, with special emphasis on the study of directional and fluctuating asymmetric variation (Klingenberg and McIntyre 1998). Our study reveals that chimpanzee-human differences in brain morphology are mainly symmetric, and that there is a clear continuity in asymmetric variation between both species. Particularly, we show that the trend to increased asymmetry is most pronounced in the posterior perisylvian area, a region closely related with Wernicke's language area. Directional asymmetries in this area are observed in both chimpanzees and humans (Hopkins et al. 1998; Toga and Thompson 2003), and are expected to be present in their last common ancestor (LCA) and elevated during hominin evolution. Our results also emphasize two key properties of brain evolution in the hominine clade: first, evolution of chimpanzee and human brains (and probably their LCA and related species) is not strongly morphologically constrained, thus making their brains highly evolvable and responsive to selective pressures; and, second, chimpanzee and, especially, human brains show high levels of fluctuating asymmetry indicative of pronounced developmental plasticity. We infer that these two characteristics can have a key role in human cognitive evolution.

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### References Cited:

- Holloway, R.L., Broadfield, D.C., Yuan, M.S., Schwartz, J.H., and Tattersall, I. 2004. *The human fossil record. Brain endocasts—The paleoneurological evidence* (Vol. 3). Wiley-Liss, New York.
- Hopkins, W.D., Marino, L., Rilling, J.K., and MacGregor, L.A. 1998. Planum temporale asymmetries in great apes as revealed by magnetic resonance imaging (MRI). *Neuro-report* 9, 2913–2918.
- Klingenberg, C.P. and McIntyre, G.S. 1998. Geometric morphometrics of developmental instability: Analyzing patterns of fluctuating asymmetry with Procrustes methods. *Evolution* 52, 1363–1375.
- Toga, A.W. and Thompson, P.M. 2003. Mapping brain asymmetry. *Nature Reviews Neuroscience* 4, 37–48.

## Confidence Limits for Mass (Not Skeletal) Dimorphism in *Australopithecus afarensis*

Adam D. Gordon, *Anthropology, University at Albany - SUNY, USA*  
 David J. Green, *Anatomy, Midwestern University, USA*  
 Brian G. Richmond, *Anthropology, The George Washington University, USA*

Here we present a new technique for estimating mass dimorphism—as opposed to skeletal dimorphism—in fossil samples. The distinction between these two types of dimorphism is particularly important because selection pressures in extant primates have been linked to mass dimorphism, not skeletal dimorphism, and the two measures differ in the two extant genera most closely related to early hominins (i.e., humans are more postcranially dimorphic but less mass dimorphic than chimpanzees). We illustrate this technique using *Australopithecus afarensis* postcrania, taking into account newly published material from Hadar. This technique builds on our earlier work using a multivariate geometric mean approach to assess skeletal dimorphism, but additionally takes into account scaling relationships between skeletal and mass dimorphism in extant species. Scaling profiles are calculated for the relationship between dimorphism in body mass and in eight measurements from the femur, tibia, humerus, and radius for four extant hominoids: *Homo sapiens* (n=50), *Gorilla gorilla* (n=50), *Pongo pygmaeus* (n=24), and *Pan troglodytes* (n=50). These scaling profiles are used to weight multivariate geometric means used in a resampling procedure to estimate mass dimorphism and confidence intervals in a fossil sample under various assumptions—that postcranial and mass dimorphism in *A. afarensis* scale as they do in humans, or as in gorillas, or as in orangutans, or as in chimpanzees. The most conservative confidence limits for mass dimorphism in *A. afarensis* (i.e., producing the lowest levels of mass dimorphism) are those based on the assumption of a human scaling pattern. In that scenario, while postcranial dimorphism in *A. afarensis* is significantly greater than that of both humans and chimpanzees, mass dimorphism in *A. afarensis* is found to be significantly greater than that of humans, but not significantly different from chimpanzees, suggesting that human-like selection pressures were not responsible for the dimorphism levels in *A. afarensis*.

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## Shells and Ornaments as Markers of Magdalenian Population Expansion

Claudine Gravel-Miguel, *School of Human Evolution and Social Change, Arizona State University, USA*

The number of studies on prehistoric population movement has been in a constant increase over the past few years due to the possibility of sourcing lithic raw materials. By looking at the movement of materials between archaeological sites, archaeologists have been able to infer the presence of movement and some sort of trade. The present research takes a slightly different approach as it uses the movement of Magdalenian unpierced and pierced shells to infer the geographical position of social networks, and the direction of diachronic population movement. Given the limitations in the possible sources of shells widely found in Southwestern Magdalenian sites, it is possible to reconstruct, using a GIS, plausible paths linking certain sites with the source of those raw materials. By doing so, one observes how the strategic location of certain sites, as for example the settlements of Canecaude and Tournal, suggests their participation in a trading/exchange system. Moreover, by sourcing and mapping the movement of relatively dated shell that would have been used as ornaments, we are able to roughly map the timing and movement of population related to Gamble et al. (2005)'s initial demic expansion following the upturn of the Last Glacial Maximum (LGM). Added to the variation in the quantity of those shell ornaments over time, this suggests that certain identifiable pierced shells were probably worn by the individuals/groups who first set up to explore new territories at the upturn of the LGM. This study demonstrates that, by simply studying shells and their movement, one can infer possible site uses, social networks extents and population movements.

### References Cited:

Gamble, C., W. Davies, P. Pettitt, L. Hazelwood and M. Richards. 2005. The archaeological and genetic foundations of the European population during the Late Glacial: implications for 'agricultural thinking,' *Cambridge Archaeological Journal* 15(02): 193–223.

## A Demographic, Social and Symbolic Framework for the Appearance of Modern Human Behavior in Sahul

Phillip Habgood, *School of Social Science, University of Queensland, AUSTRALIA*

Natalie Franklin, *School of Social Science, University of Queensland, AUSTRALIA*

A focus of debate over the past two decades has been the definition of modern human behavior via lists of innovations or traits that are claimed to reflect it and the appearance of this “package” of traits within the archaeological record. Late Pleistocene Sahul has provided a test for the debate as it was a continent settled by anatomically and behaviorally modern humans. We previously reviewed the late Pleistocene archaeological record of Sahul and found that the components of the package were gradually assembled over a 30,000-year period following initial occupation and that there was both chronological and geographical patterning in the appearance of the individual traits. This review demonstrated that there is no package of archaeologically visible traits that can be used to establish modern human behavior. We concluded that the pattern for the appearance of the traits reflects material culture differences and cultural preferences. This presentation uses Sahul to further assess explanations for the appearance and, importantly, the disappearance of the traits from the archaeological record. It explores the impact of ecological and demographic changes during late Pleistocene-early Holocene Sahul on symbolic and other behaviors. This demographic, social, and symbolic framework has implications for explanations for the appearance of the package in Europe and Africa.

## Evolutionary Trends and Correlation of Morphology and Function in Mandibular Fourth Premolars of Early Hominins

Yohannes Haile-Selassie, *Physical Anthropology, Cleveland Museum of Natural History, USA*

Pliocene hominin mandibular fourth premolar (P4) crown morphology and root number are usually considered as polymorphic and hence less informative for delineating early hominin taxonomy and phylogenetic relationships or inferences related to dietary adaptations. However, most of the P4s available in the fossil record are heavily worn and do not allow for detailed morphometric analysis. Thirteen unworn or slightly worn P4s of early *Australopithecus* have been recovered from the Woranso-Mille study area in sediments dated to between 3.6 and 3.8 million years ago. Preliminary morphometric analysis of these and some unworn specimens of *Ardipithecus ramidus*, *Australopithecus anamensis*, and *Australopithecus afarensis* indicate the presence of inter-specific differences in the occlusal morphology of early hominin P4s. Using ImageJ 64, the crown outline, trigonid/talonid area, and position of the main cusps of 25 Pliocene (3.0–4.4 Million years ago) hominin P4s were quantified. The results indicate that P4 crown morphology of *Ardipithecus ramidus* and *Au. anamensis* is different from all later *Australopithecus* taxa. First, *Ar. ramidus* and *Au. anamensis* P4s have an elongated oval occlusal outline, whereas substantial amount of asymmetry in occlusal shape is apparent in all other *Australopithecus* species. This asymmetry is associated with reduction of the mesial fovea and expansion of the talonid, particularly distolingually. The distolingual bulging of the talonid, resulting in an increase of the occlusal surface of the crown, is more likely the cause for the increase in the root number of P4s in almost all *Australopithecus* taxa. Moreover, it appears that in *Australopithecus afarensis* the protoconid and metaconid are repositioned more mesially than in *Ar. ramidus* and *Au. afarensis*, resulting in the reduction of the trigonid area and expansion of the talonid for crushing and grinding. Further work on the microwear of the premolars will be necessary to test these observations. These findings suggest the taxonomic and phylogenetic importance of P4s and lend support to hypothesized differences in the dietary adaptations of *Ar. ramidus*/*Au. anamensis* and *Au. afarensis*.

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## Middle Miocene Hominid *Pierolapithecus* Provides Insight into Early Hominid Pelvic Morphology

Ashley S. Hammond, *Pathology and Anatomical Sciences, University of Missouri School of Medicine, USA*

David M. Alba, *Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, SPAIN; and, Università degli Studi di Torino, Turin, ITALY*

Sergio Almécija, *Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, SPAIN; and, Department of Vertebrate Paleontology, American Museum of Natural History and NYCEP, USA; and Department of Anatomical Sciences, Stony Brook University, USA*

Salvador Moyà-Solà, *ICREA at Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, SPAIN*

*Pierolapithecus catalaunicus* is a middle Miocene (11.9 Ma) stem hominid from BCV1 in Abocador de Can Mata (Catalonia, Spain) consisting of an associated partial skeleton preserving, amongst others, the oldest known great ape pelvic remains in the fossil record—a partial ilium (IPS-21350.38) and ischium (IPS-21350.39). However, the fragmentary nature of these materials has precluded reliable numerical analyses in the past. Here, the use of novel three-dimensional nonlandmark-based morphometric techniques allows us to describe and analyze this important fossil pelvis within a comparative context, providing insight into the pelvic structure that characterized stem hominids. The ilium of *Pierolapithecus* was compared to a broad sample of laser scanned anthropoids and to that of the stem African hominoid *Proconsul nyanzae* (KNM-MW 13142)—virtually the only comparable fossil specimen. Linear measures were collected from transverse cross-sections created at the level of the iliac isthmus and caudal to the posterior inferior iliac spine on pelvic polygonal models within PolyWorks software. In addition, qualitative descriptions of the original *Pierolapithecus* pelvis fossils are provided. The ilium of *Pierolapithecus* is *Proconsul*-like in sacroiliac joint shape, iliac isthmus structure, and in having a deeply concave gluteal surface. However, the ilium may be more laterally flaring than *Proconsul* and iliac tuberosity width is probably intermediate between monkeys and apes. Although the *Pierolapithecus* ischium consists of just a small fragment, the morphology is consistent with *Proconsul*. Overall, the *Pierolapithecus* pelvis is primitive but displays modifications probably associated with the more frequent use of orthograde behaviors, as described for this taxon on the basis of other preserved anatomical regions. Moreover, it suggests that extant ape pelvic morphology could be homoplastic given any of the hypothesized phylogenetic positions of *Pierolapithecus* (i.e., stem great ape vs. stem African ape), and has implications for reconstructing the basal hominid bodyplan from which later hominids evolved.

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## Isotopic Evidence for Temporal Change in Neanderthal Hunting Ranges at Amud Cave, Israel

Gideon Hartman, *Anthropology, University of Connecticut, USA*

Erella Hovers, *Institute of Archaeology, The Hebrew University of Jerusalem, ISRAEL*

Michael Richards, *Anthropology, University of British Columbia, CANADA; and, Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, GERMANY*

The site of Amud cave, located 5km northwest of the Sea of Galilee, was inhabited by Neanderthals in two temporally distinct occupational phases—the first ca. 70 kya (MIS 4) and the second ca. 55 kya (MIS 3). Aspects of material culture, in particular the lithic assemblage reflect nuanced differences in land use patterns in the two occupations. Strontium (Sr) isotope ratios and concentrations measured in the tooth enamel of the dominant prey species (gazelle), show a marked change in the hunting ranges of Neanderthals between the early and late occupations. During the early phase, gazelles were hunted at higher elevations to the west of the site, but in the later phase hunting shifted to lower elevations immediately adjacent to the site and eastward towards Lake Lisan, the predecessor of Sea of Galilee. This argument is based on bioavailable Sr ratio maps constructed by the authors following intensive regional sampling of plants and invertebrates, and taking into account differential contribution of local bedrock weathering and atmospheric deposition to the bioavailable Sr pool. A more precise reconstruction of the orographic ranges from which gazelles were brought to the site is currently underway using serial sampling of oxygen and carbon isotope values in the same teeth that provided the strontium data. Among the potential explanations for the disparate hunting ranges are climatic and environmental change with the onset of MIS3, changes in the season of site occupation from the warm to the cold season, or a reorganization of Neanderthal hunting strategies. The strontium mapping presented in this study offers a new opportunity to detect Neanderthal ranging patterns. The technique will complement zooarchaeological and lithic research to enable more nuanced reconstructions of Neanderthal behavior.

## What Can We Learn From Fossil Footprints? Multivariate Predictive Models for Inferring Anatomical and Functional Variables From Fossil Hominin Footprint Morphologies

Kevin G. Hatala, *Department of Anthropology, The George Washington University, USA; and, Hominid Paleobiology Doctoral Program, Center for the Advanced Study of Hominid Paleobiology, The George Washington University, USA*

Roshna E. Wunderlich, *Department of Biology, James Madison University, USA*

Heather L. Dingwall, *Department of Human Evolutionary Biology, Harvard University, USA*

Brian G. Richmond, *Department of Anthropology, The George Washington University, USA; and, Center for the Advanced Study of Hominid Paleobiology, The George Washington University; and, Human Origins Program, Smithsonian Institution, USA*

Fossil hominin footprints preserve unique, direct records of the foot anatomy, foot function, and gait of our extinct relatives. However, the interpretation of fossil footprints has been constrained by our limited understanding of the relationships between footprint shape and anatomical and biomechanical variables. Here, we present results from footprint formation experiments, conducted with 35 adult and juvenile Daasanach from northern Kenya. A pressure pad was placed in the middle of a trackway, followed by a pit (c. 15cm deep) filled with rehydrated sediment from a 1.5 Ma layer containing fossil hominin footprints. Biometric measurements were taken from each subject, and they walked and ran along the trackway for at least three trials at each of four speeds (normal walk, fast walk, jog, fast run; later quantified from video). In each trial, we quantified variables related to the subject's foot anatomy, foot function, and gait, and measured the rehydrated sediment's resistance to deformation (kg/cm<sup>2</sup>). Photogrammetry was used to produce 3-dimensional models of the footprints created in the sediment patch during each trial. We found several statistically significant correlations ( $p < 0.05$ ) between measures of footprint morphology and measures of foot anatomy and gait (e.g., plantar pressure distribution and footprint topography, Spearman's  $\rho = 0.38$  at walking speeds). However, despite their statistically significant correlations, no single variable explained more than 20% of variance in footprint topography. We therefore used geometric morphometric techniques to determine principal axes of footprint shape variation, and constructed multiple regression models to describe principal shape variation in terms of multiple variables related to foot anatomy, foot function, and gait. This analysis provides a quantitative framework for interpreting specific anatomical and biomechanical variables from fossil hominin footprints and demonstrates how those factors influence the overall morphology of footprints.

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## Recent Research on the Middle Stone Age of Coastal Mozambique

Jonathan A. Haws, *Anthropology, University of Louisville, USA*

Julien Riel-Salvatore, *Anthropology, University of Colorado-Denver, USA*

Nuno F. Bicho, *Universidade do Algarve, PORTUGAL*

Omar Madime, *Departamento de Arqueologia e Antropologia, Universidade Eduardo Mondlane, MOZAMBIQUE*

Michael Benedetti, *Department of Geography & Geology, University of North Carolina Wilmington, USA*

Leonardo Adamowicz, *Departamento de Arqueologia e Antropologia, Universidade Eduardo Mondlane, MOZAMBIQUE*

Hilario Matiquida, *Departamento de Arqueologia e Antropologia, Universidade Eduardo Mondlane, MOZAMBIQUE*

This paper presents the preliminary results of the 2012 field season of a new project investigating the Middle Stone Age of coastal Mozambique. Located between modern-day South Africa and Tanzania, both of which have well-known and extensive Stone Age records, Mozambique and its Stone Age sequence remain largely unknown in the broader context of African Pleistocene prehistory. This is in spite of the country occupying a critical position, linking as it does southern and eastern Africa, and of its clear potential to inform various scenarios about recent human evolution. Specifically, the geography of Mozambique makes its sea coast a natural area of interest to evaluate recent scenarios about the importance of coastal adaptations to the success and diffusion of *Homo sapiens* outside of southern Africa. Here, we report on the results of a survey undertaken in southernmost Mozambique aimed at identifying Middle Stone Age deposits. We report the existence of localities displaying unambiguous evidence of prepared core technology. Interestingly, these localities are found both on the coast of the Indian Ocean (e.g., Ponta Moane) as well as several dozen kilometers inland (e.g., Goba sites). This suggests a broad-based Middle Stone Age occupation of the area that incorporated both coastal and interior environments. While fieldwork is ongoing, these results underscore the rich potential of Mozambique to inform human biological and cultural evolution in the Middle and Late Pleistocene.

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## Working Hard or Hardly Working? A Preliminary Study of the Metabolic Costs of Stone Knapping

Eric Hefter, *School of Anthropology, The University of Arizona, USA*

David Raichlen, *School of Anthropology, The University of Arizona, USA*

Steven Kuhn, *School of Anthropology, The University of Arizona, USA*

Although the importance of stone knapping in human evolution is widely recognized, surprisingly little is known about the temporal or energetic costs of flaking activities. This paper presents preliminary findings from an experimental study of metabolic costs of three different techniques for flaking stone—hard hammer direct percussion, soft hammer direct percussion, and pressure flaking. These techniques appear in human evolutionary history in the order presented, with hard hammer percussion being the oldest and pressure flaking being the most recent. The techniques do not appear to have different cognitive requirements. A reasonable hypothesis is that they have differing costs, and that the successive addition of techniques represents changing investment in stone artifacts over time. Moreover, anecdotal reports from knappers suggest that pressure flaking is the most demanding (tiring) activity. The preliminary

experiment involved five subjects, ranging from moderately to very skilled. Results indicate that: 1) knapping activities are moderately costly, roughly equivalent to walking; and, 2) metabolic costs of different techniques, measured against time, do not show statistically significant differences. These findings have direct implications for how we might assess the costs of different kinds of artifacts, as well as how we could model trade-offs between raw material procurement and manufacture activities.

**Acknowledgements:** The authors would like to thank Allen Denoyer, James Webber, and our experimental volunteers.

## New Research at the Buxton-Norlim Limeworks, South Africa: Paleomagnetic Analysis and Preliminary Ages for the Taung Child Bearing Deposits of the Dart and Hrdlička Pinnacles and New Excavations at Equus Cave

Andy I.R. Herries, *Australian Archaeomagnetism Laboratory, Department of Archaeology, Environment and Planning, La Trobe University, AUSTRALIA*

Brian Kuhn, *Institute of Human Evolution, University of the Witwatersrand, SOUTH AFRICA*

Matt Caruana, *School of Geography, Archaeology & Environmental Studies, University of the Witwatersrand, SOUTH AFRICA*

Stephanie Baker, *Institute of Human Evolution, University of the Witwatersrand, SOUTH AFRICA*

Rhiannon Stammers, *Australian Archaeomagnetism Laboratory, Department of Archaeology, Environment and Planning, La Trobe University, AUSTRALIA*

Colin G. Menter, *Centre for Anthropological Research, University of Johannesburg, SOUTH AFRICA*

The focus of new research at Taung has been an analysis of the remaining tufa and other deposits associated with the 'Hrdlička' and Dart Pinnacles, the source of the majority of the Plio-Pleistocene fossils from the limeworks, including the type specimen of *Au. africanus*, the 'Taung Child.' Sedimentological analysis has established that the Taung Child comes from the older pink deposits, while most of the fauna used to faunally date the site comes from the red deposits. Stratigraphic analysis indicates that the pink deposits formed synchronously with the Thabaseek tufa and that they are stratified within it, while the red deposits formed much later, in-filling solution fissures within both the pink deposits and tufa. Paleomagnetic analysis indicates that the older pink deposits and tufa unit records a normal magnetic polarity for much of its depth with a few reversed magnetic polarity layers towards its top. In contrast the red deposits record only a reversed magnetic polarity. The polarity is consistent for different outcrops of the same units, suggesting they were deposited at roughly the same time no matter which Pinnacle they outcrop in. Given the fauna recovered, the red deposits are correlated to the Matuyama Chron between 2.58 and 1.95 Ma, but likely towards the end of this period. The majority of the Pink deposits and tufa from which the Taung Child was recovered formed during the Gauss Chron 3.6–2.6 Ma, perhaps contemporary with the Makapansgat Limeworks Member 3 between 3.0 and 2.6 Ma and likely around 2.6 Ma. The published faunal record has been augmented by the study of fossils that were recovered from the 1988–1992 excavations at the site, but which were seemingly abandoned on site and whose context has been lost in many cases. New excavations of the 'Homo sapiens' bearing Equus Cave have also begun.

## Did the Châtelperronian Result From Independent Invention or From Cultural Diffusion?

Jean-Jacques Hublin, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*

In western Eurasia, at the time of the replacement of the last Neandertals by modern humans, several assemblages are designated as "transitional industries" (TA). These are found under early Upper Paleolithic (UP) layers (mostly Aurignacian) and/or above classic Middle Paleolithic assemblages. To date, the biological identity of the makers of these assemblages remains in most cases unclear. Some TA, especially in eastern and central Europe, might represent an initial UP associated with the arrival of the very first modern people in Europe. However, a direct origin in the local Middle Paleolithic has been also often argued. In western Europe, the Châtelperronian (CP) stands as the only TA that has yielded well-identified and relatively numerous diagnostic Neandertal remains. It also displays a wider range of UP behaviors, including the production of bladelets, rather simple bone artifacts, and pendants. The fabrication processes of these artifacts in the CP and in Aurignacian assemblages can be, however, contrasted. Furthermore, recent investigations at the key site of the Grotte du Renne (France) have demonstrated that large scale layer admixture is not a viable explanation for the occurrence of these artifacts and Neandertal remains in the CP layers. The direct dating of the Saint-Césaire (France) Neandertal skeleton also brings support to the Neandertal origin of the CP. When only high precision AMS <sup>14</sup>C dates obtained on samples with a good pretreatments are considered, the CP assemblages can be assigned to a time window contemporaneous to the first Proto-Aurignacian of southern France and northern Italy and to the earliest Aurignacian from Germany and Austria, both most likely produced by modern humans. Although lasting local co-existence of the two groups is unlikely, cultural diffusion at distance from modern newcomers to local populations of late Neandertals still stands as the most parsimonious explanation for the observed pattern.

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## Quaternary Glacioeustatic Record and Hominin Paleobiogeography of the Sunda Lowlands, Southeast Asia

O. Frank Huffman, *Department of Anthropology, University of Texas at Austin, USA*

Henry W. Posamentier, *Chevron Energy Technology Company, USA*

Lesli J. Wood, *Bureau of Economic Geology, University of Texas at Austin, USA*

John de Vos, *Naturalis Biodiversity Center, THE NETHERLANDS*  
 Antoine Balzeau, *Département de Préhistoire, Muséum national d'histoire naturelle, FRANCE*  
 Aart W. Berkhout, *USA*

Petroleum- and mining-industry seismic and drilling data document strong glacioeustatic impacts on the Sunda Shelf, the 1.8 million-square-kilometer shallow sea situated between Java and Indochina. The record helps assess when and where Pleistocene hominins inhabited Southeast Asia outside the few *Homo erectus*, *Homo floresiensis*, and *Homo sapiens* discovery areas. The Quaternary (0–2.6 Ma) beneath the shelf commonly overlies marine Pliocene, and contains a vertical repetition of lowland paleo-landscape indicators, such as low-gradient erosional surfaces with valley fills. The succession generally reflects well-established post-Pliocene glacioeustatic events—declining average sea-level, vast fluctuations in the size of continental-margin lowlands as global ice-volumes varied, and higher amplitude changes after the Mid-Pleistocene transition, ending rapidly with Holocene inundation. The paleo-landscape indicators in some areas include those representing earliest Pleistocene terrains in which large-mammal taxa of South Asian lineage (known now only from Java) and *Homo erectus* and/or *Homo floresiensis* ancestors could have lived long before the oldest-dated hominin fossils in Java (~1.5 Ma). Localized 3D-seismic data sets reveal frequent variations in large Pleistocene lowland rivers, changes that probably affected biotic dispersal pathways, perhaps even at millennial scale. Each sea-level fluctuation assuredly altered what coastal resources were available. The largest falls produced immense incised landscapes, where (hypothetically and to undetermined extent) better interfluvial drainage and seasonally desiccated soils expanded open vegetation beneficial to large-herbivore- and hominin-habitation. For example, lowland expansion beginning ~70 ka ago most likely helped *Homo sapiens* disperse across Sundaland towards Australasia (by then, Borneo, Sumatra, and Java probably were connected by divides separating rivers that headed south, north and east). Conversely, peak highstands forced lowland populations toward Southeast Asia's mainland and permanent islands (for instance, possibly instigating *Homo sapiens'* move into Flores Island). Glacioeustatic expansion-contraction of the Sunda lowlands therefore probably introduced a pulsing complexity into the hominin biogeography of Southeast Asia.

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## **eFossils.org: A Collaborative Website and Community Database for the Study of Human Evolution**

John Kappelman, *Anthropology, The University of Texas at Austin, USA*  
 Peter Keane, *Instructional Technology Services, The University of Texas at Austin, USA*  
 Denné Reed, *Anthropology, The University of Texas at Austin, USA*  
 Joseph Tenbarger, *Instructional Technology Services, The University of Texas at Austin, USA*  
 Adrienne P. Witzel, *Anthropology, The University of Texas at Austin, USA*  
 W. Andrew Barr, *Anthropology, The University of Texas at Austin, USA*  
 Brett A. Nachman, *Anthropology, The University of Texas at Austin, USA*  
 Gabrielle A. Russo, *Anthropology, The University of Texas at Austin, USA*

The evidence for human evolution has witnessed a dramatic expansion over the past 30 years and the rapid growth of the fossil and archaeological records has challenged the traditional approaches of a classroom lecture and hands-on laboratory. In order to provide current information to students, we have built a robust collaborative website, [eFossils.org](http://eFossils.org). This website incorporates various data from human evolution (e.g., anatomy, geology, geography, geochronology) within a multimedia learning environment (e.g., color images, 3D animations, video) and offers a series of online tools to visually represent these data and permit their study. The eFossils catalog uses the Darwin Core schema and permits the display and mapping of data sets from any project. The website also includes a “collaboratorium,” a web tool built on a generic template that permits the research community to collaborate on large-scale problems. Collecting all the information for human evolution into a single database is now too large an undertaking for any one group; instead, eFossils is constructed for the collaborative participation of subject-matter experts. We have populated eFossils with several site reports about key hominin fossil localities in order to seed the process of providing a data-rich online presentation. Additional localities can be populated through a collaborative expansion of the database by registered users. Consequently, the organic nature of eFossils reflects the dynamic nature of the field, and as users expand the database with their own research, the “ownership” of the site will transfer to the user community in a manner that mirrors the online expert wikis.

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## **Paleo-Forensics: Could Soft Organic Tissue Have Preserved With the Plio-Pleistocene Aged Hominins From the Malapa Cave Site, South Africa?**

Rachelle Keeling, *Institute for Human Evolution, School of GeoSciences, University of the Witwatersrand, SOUTH AFRICA*  
 Lee R. Berger, *Institute for Human Evolution, School of GeoSciences, University of the Witwatersrand, SOUTH AFRICA*

Soft parts in the form of dermal skin tissue may have preserved with the near complete *Australopithecus sediba* hominin specimens from the Malapa site, South Africa. The taphonomic condition of the fossils suggests rapid burial, lack of predation, but some insect damage, making the preservation environment at Malapa exceptional. Any soft tissue found with the almost two million year old hominins, represented by MH1 (Malapa Hominid 1) and MH2 (Malapa Hominid 2) would be of some considerable value, since such preservation

is at present unrecognized in the early hominin record. Soft tissue has, however, been recovered from dinosaur, amphibian, and mammal fossilized remains. The Malapa specimens were analyzed using a multidisciplinary approach that combined morphological techniques (optical coherence tomography, three-dimensional laser scans, micro-CT scans, and light microscopy) in association with molecular imaging (Raman spectroscopy and Fourier transform infrared) to determine if original organics may be recovered. The investigation focused on two primary specimens—a cranium sample from MH1 and mandible specimen from MH2. The examination included an analysis of soft tissue decomposition potential to determine whether the depositional environment may have facilitated soft tissue preservation. Overall the study produced a provocative body of evidence that the specimens were indeed organic in origin. The significance of such a discovery could provide insight into our understanding of ancient hominin biology and evolution by generating information on hominin skin morphology—which would enable comparative analyses against *Homo sapien sapiens*. Such a find would also contribute to our knowledge of taphonomic processes by highlighting the various sedimentary conditions that determine optimal organic preservation and how these impact the fossilization process.

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## Complete Mitochondrial Genomes of Early Modern Humans Suggest Late Out of Africa Migration

Johannes Krause, *Institute for Archaeological Sciences, University of Tuebingen, GERMANY*

Differences between DNA sequences correspond to nucleotide substitutions that have accumulated since their split from a most recent common ancestor (MRCA). When temporal estimates for the divergence event are available, the average number of substitutions occurring per unit time can be determined. This is the basis for the molecular clock, and under the assumption of constant rates amongst lineages, it has been used to estimate divergence times between closely related species, as well as temporal estimates for demographic events within populations. Radiocarbon dates for fossil material have been popularly used to estimate a date for the MRCA of two species or populations, hence providing a calibration for the molecular clock. Recent analyses of *de novo* DNA mutations in genome-wide investigations of modern humans suggest a nuclear substitution rate that is half that of previous estimates based on fossil calibration. The application of this new rate has led to revisions of major events in human evolution such as the time of our divergence from our common ancestors with either chimpanzees or other closely related hominins, and the out of Africa migration of modern humans. Here we use the complete mitochondrial genome sequences from 10 securely dated early modern humans spanning 40,000 years of human history as calibration points for the mitochondrial clock, thus yielding a reliable estimate of the human mitochondrial substitution rate. Our rate is similar to previous estimates based on fossil calibration. Application of our rate yields a best fit date for the modern human mitochondrial divergence of 157 kya, which is 90 kya younger than recent estimates of the population split time based on the *de novo* genomic rates.

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## Comparisons of Rotator Cuff Muscle Use in Chimpanzees, Gibbons and Orangutans: How Are We to Interpret Differences in Scapular Fossa Size?

Susan Larson, *Anatomical Sciences, Stony Brook University School of Medicine, USA*  
 Jack Stern, *Anatomical Sciences, Stony Brook University School of Medicine, USA*

It has long been recognized that many aspects of primate scapular form can be related to habitual locomotion, making fossil scapular specimens useful in reconstructing the behavior of extinct species. Interest in understanding how the forelimb of early bipeds was used makes hominin fossil scapulae particularly valuable. For many years only small portions of hominin scapulae were known, but the recent discovery of several more complete specimens has begun to fill that gap. This has led to renewed interest in the comparative analysis of human and extant ape scapular form. A major focus of these studies is comparison of supraspinous to infraspinous fossa size as an indicator of the importance of overhead use of the forelimb. Paradoxically, the African apes, the most terrestrial of the great apes, have higher scapula fossa ratios than more suspensory orangutans, which in turn, are more similar to humans than are the African apes. To identify a basis for these apparent differences in muscle use, we used electromyography (EMG) to document the activity patterns in all four rotator cuff muscles in orangutans and gibbons, comparing the results to previously published data for chimpanzees. The EMG results indicate that the distinctive contributions of each cuff muscle are the same in the three ape species—*infraspinatus* and *teres minor* help resist transarticular stress during suspension; *supraspinatus* and *infraspinatus* are important in arm-raising and in resisting shear stress during quadrupedal behaviors; and, *subscapularis* acts during the pull-up phase of climbing. If the rotator cuff muscles are used in the same ways in all apes, how are we to understand differences in relative scapular fossa size? Exploration of the actual sizes of the rotator cuff muscles indicates that the emphasis on relative scapular fossa size has given a false impression of the importance of individual cuff muscles to locomotor differences among apes.

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## Feeding Biomechanics of *Australopithecus sediba* Examined Using Finite Element Analysis

Justin Ledogar, *Anthropology, University at Albany, USA*  
 Kristian Carlson, *Institute for Human Evolution, University of the Witwatersrand, SOUTH AFRICA*  
 Stefano Benazzi, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Gerhard Weber, *Anthropology, University of Vienna, AUSTRIA*  
 Lee Berger, *Institute for Human Evolution, University of the Witwatersrand, SOUTH AFRICA*  
 Darryl de Ruiter, *Anthropology, Texas A&M University, USA*  
 Amanda Smith, *Anthropology, University at Albany, USA*  
 Mark Spencer, *School of Human Evolution and Social Change, Arizona State University, USA*  
 Ian Grosse, *Mechanical & Industrial Engineering, University of Massachusetts at Amherst, USA*  
 Callum Ross, *Organismal Biology & Anatomy, University of Chicago, USA*  
 Paul Dechow, *Biomedical Sciences, Texas A&M Health Science Center, Baylor College of Dentistry, USA*  
 Brian Richmond, *Center for the Advanced Study of Hominid Paleobiology, Department of Anthropology, The George Washington University, USA*  
 Peter Lucas, *Bioclinical Sciences Faculty of Dentistry, Kuwait University, KUWAIT*  
 Qian Wang, *Division of Basic Medical Sciences, Mercer University School of Medicine, USA*  
 Craig Byron, *Biology, Mercer University, USA*  
 Barth Wright, *Anatomy, Kansas City University of Medicine and Biosciences, USA*  
 Dennis Slice, *School of Computational Science & Department of Biological Science, Florida State University, USA*  
 David Strait, *Anthropology, University at Albany, USA*

The cranium of MH1, the type specimen of *Australopithecus sediba*, preserves relatively small cheek teeth and lacks most of the facial buttressing features characteristic of other australopiths, suggesting that the cranium is not well designed to withstand high feeding loads. However, the specimen also exhibits a vertically deep zygomatic root with a straight zygomaticoalveolar crest, and dental microwear suggests the presence of hard foods in its diet (implying the generation of high bite forces). Here we test the structural strength of the MH1 cranium using finite element analysis, an engineering method commonly used to examine how objects of complex geometry and material properties respond to load. A surface model of the MH1 cranium was virtually reconstructed to correct for displaced, damaged or missing parts. The reconstruction was converted to a finite element mesh, assigned the material properties of chimpanzee craniofacial bone, constrained at the temporomandibular joints (TMJs) and bite points at the molars and premolars, and subjected to isometrically scaled jaw adductor loads. Strains in the MH1 model were then compared to those found in finite element models of *Australopithecus africanus* (Sts 5), *Paranthropus boisei* (OH 5) and six chimpanzees. Results indicate that the face of MH1 is surprisingly strong, with certain measures of strain being proportionally as low as those found in OH 5. However, analysis of facial biomechanics indicates that MH1 may not be optimized to produce high unilateral molar bite force. Thus, the face of MH1 may be stronger than needed in relation to the unilateral bite forces it was capable of producing.

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## Using Mammalian Microfauna to Reconstruct Hominin Paleohabitats in South Africa

Jennifer Leichliter, *Anthropology, University of Colorado Boulder, USA*  
 Oliver Paine, *Anthropology, University of Colorado Boulder, USA*  
 Matt Sponheimer, *Anthropology, University of Colorado Boulder, USA*  
 Paul Sandberg, *Anthropology, University of Colorado Boulder, USA*  
 Darryl deRuiter, *Anthropology, Texas A&M University, USA*  
 Nico Avenant, *Mammalogy, Bloemfontein National Museum and Centre for Environmental Management University of the Free State, SOUTH AFRICA*  
 Daryl Codron, *Florissbad Quaternary Research, National Museum, Bloemfontein, SOUTH AFRICA*

Fossilized faunal remains have long been used to infer paleoenvironmental conditions at hominin-bearing localities, but mammalian microfauna have been underutilized despite their abundance in the fossil record. One difficulty in using micromammals to reconstruct past environments is that the specific habitat and dietary affinities of many modern species remain unresolved. The diets and habitats of micromammal species can also vary significantly from region to region. This study refines our understanding of micromammal ecology within the Cradle of Humankind World Heritage Site, South Africa. We anticipated that certain microhabitat types would be characterized by unique small mammal community structures and that habitat and dietary generalists would have highly variable diets. We assessed small mammal community structure using samples collected from accumulated pellets at roost sites of the African Barn Owl (*Tyto alba*) and trap lines. Roost and trapping sites were located within different microhabitat types ranging from open grassland to closed, wooded areas. In addition, stable isotope analyses were conducted on hair and tooth enamel samples to investigate diet. Our results indicate that despite their relative proximity, microhabitats are characterized by distinct differences in diversity and relative abundance of micromammal species. Furthermore, we find that isotopic values, while variable in generalist species, are highly variable even in many species with purportedly narrow habitat and dietary preferences. We discuss the implications of these findings for paleohabitat reconstruction generally and provide preliminary assessments of the Sterkfontein, Swartkrans, Kromdraai, and Gladysvale micromammal assemblages.

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## Landscape Environmental Reconstructions for the Kapthurin Formation, Kenya

David Leslie, *Anthropology, University of Connecticut, USA*

The Kapthurin Formation is part of the Middle Pleistocene sedimentary sequence of the Kenyan Rift Valley, lying to the west of Lake Baringo. The Kapthurin Formation documents the transition from Acheulean to the Middle Stone Age (Tryon and McBrearty 2002), a time period characterized by significant technological innovation and the appearance of *Homo sapiens* (McBrearty and Brooks 2000). Bovid teeth, housed in the National Museums of Kenya, were sampled from the following archaeological and paleontological sites of the Kapthurin Formation, GnJh-23, GnJh-38, GnJh-41, GnJh-47, GnJh-52, GnJh-53, GnJh-56, GnJh-58, and Loc. 4. These sites are located stratigraphically below the Grey Tuff, dated to 509 ka (Deino and McBrearty 2002). Taxa that were sampled include Neotragini, Reduncini, Tragelaphini, Alcelaphini, Cephalophini, and Bovini and were identified according to Gentry (1978). Teeth were sampled using a dental drill (Vogue 6000) applying serial sampling protocols set forward by Balasse (2003). Fossil teeth were sampled horizontally in bands perpendicular to the growth axis of the tooth crown, at an interval of approximately 1.5mm, starting at the cervix and ending at the apex. Samples of tooth enamel were sent to the CNRS mass spectrometry lab for analysis. Preliminary results of carbon ( $\delta^{13}\text{C}$ ) and oxygen ( $\delta^{18}\text{O}$ ) values indicate a diverse landscape with a mixture of arid grassland ( $\text{C}_4$ ) and wet forested ( $\text{C}_3$ ) environments. Future work will focus on expanding taxa for isotopic analyses and will include paleosols, pedogenic carbonates, and soil organics, to holistically reconstruct paleo-environments. Reconstructing environments using this landscape perspective could prove useful in determining the factors that led to biological and technological change (Potts 1998), culminating with the emergence of the Middle Stone Age and eventually *Homo sapiens*.

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### References Cited:

- Balasse, M. 2003. Potential biases in sampling design and interpretation of intra-tooth isotope analysis. *International Journal of Osteoarchaeology* 13, 3–10.
- Deino, A. and McBrearty, S. 2002.  $^{40}\text{Ar}/^{39}\text{Ar}$  Dating of the Kapthurin Formation, Baringo, Kenya. *Journal of Human Evolution* 42, 185–210.
- Gentry, A.W. 1978. Bovidae. In: Maglio, Cooke, H.B.S., (eds.), *Evolution of African Mammals*. Harvard University Press, Cambridge, pp. 540–572.
- McBrearty, S. and 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.
- Potts, R. 1998. Variability selection in hominid evolution. *Evolutionary Anthropology* 7, 81–96.
- Tryon, C.A. and McBrearty S. 2002. Tephrostratigraphy and the Acheulean to Middle Stone Age transition in the Kapthurin Formation, Kenya. *Journal of Human Evolution* 42, 211–235.

## Correlations Between Orthograde Climbing and Scapular Morphology in Wild Chimpanzees, with Implications for *Australopithecus afarensis*

Marisa Macias, *Evolutionary Anthropology, Duke University, USA*  
Joseph Feldblum, *Evolutionary Anthropology, Duke University, USA*

Recent discoveries of two relatively complete *Australopithecus afarensis* scapulae from Dikika and Woranso-Mille, Ethiopia, allow for renewed inquiry into *Au.* arboreality. Current analyses of the morphological affinities of these fossils to extant hominoids have led to disparate conclusions. Haile-Selassie et al. (2010) suggest *Au. afarensis* may have had a *Homo*-like shoulder while Green and Alemseged (2012) suggest an ape-like shoulder, thus confounding conclusions about the *Au.* behavioral repertoire. Comparative functional morphology can illuminate the relationship between anatomical variation and climbing mechanics, but previous efforts to characterize hominoid positional behavior focused on overall patterns of behavior rather than the mechanics of specific locomotor categories. For the current study, we analyze the relationship between orthograde climbing mechanics and scapular morphology in wild chimpanzees. Preliminary analysis of over 35 hours of video shot at Gombe National Park, Tanzania, suggest important differences in overhead reaching between small- and large-bodied chimpanzees. Specifically, smaller chimpanzees initiated higher contact with vertical substrates while reaching during vertical climbing (mean difference of 9 degrees in the angle between the upper limb and thorax). Larson and Stern (1986) recognized the deltoid, supraspinatus, and infraspinatus muscles as active during the overhead reaching phase of vertical climbing in chimpanzees. On the basis of our locomotor analyses, we hypothesized that small-bodied chimpanzee scapulae would have relatively larger muscular origins for these muscles and confer mechanical advantage across the scapulohumeral joint. We further hypothesized that the juvenile Dikika scapula would be morphologically similar to small chimpanzees. Results support our hypotheses—smaller chimpanzees have greater mechanical advantage for overhead reaching, and the Dikika scapula is not significantly different from those of smaller chimpanzees. These results suggest that the scapular morphology of *Au. afarensis* is consistent with a pattern of vertical climbing similar to that seen in small-bodied chimpanzees.

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### References Cited:

- Green, D.J. and Z. Alemseged. 2012. *Australopithecus afarensis* Scapular Ontogeny, Function, and the Role of Climbing in Human Evolution. *Science* 338(6106): 514–517.
- Haile-Selassie, Yohannes, Bruce M Latimer, Mulugeta Alene, et al. 2010. An early *Australopithecus afarensis* postcranium from Woranso-Mille, Ethiopia. *Proceedings of the National Academy of Sciences USA* 107(27): 12121–12126.
- Larson, S.G. and J.T. Stern. 1986. EMG of scapulohumeral muscles in the chimpanzee during reaching and "arboreal" locomotion. *American Journal of Anatomy* 176(2): 171–190.

## Transitions and Terminations: Spatial and Temporal Patterning at the End of the Howiesons Poort Industry in South Africa

Alex Mackay, *School of Archaeology and Anthropology, Australian National University, AUSTRALIA*

The Howiesons Poort industry of southern Africa's late Pleistocene is prolific with respect to the number and spatial distribution of known shelter sites. The industry appears to cease with the end of MIS 4 in most places, giving way to post-Howiesons Poort assemblages in early MIS 3. This paper explores spatial patterns in technological and occupational responses to the MIS 4/3 shift. It is shown that Howiesons Poort sequences are variable within late MIS 4 across South Africa, and that the end of MIS 4 is marked by a mix of technological transitions and occupational terminations. Spatial patterns in these responses provide clear insights into the causes underlying the demise of the Howiesons Poort.

## The Functional Morphology of the Scapula

Sandra Mathews, *Centre for Evolutionary Medicine, Institute for Anatomy, University of Zurich, SWITZERLAND*  
Peter Schmid, *Anthropological Institute & Museum, University of Zurich, SWITZERLAND*

The shoulder girdle is involved in nearly every act of locomotion. Several features of the scapula can be identified that differ among different primate species. This allows classification of primates according to their mode of locomotion and reconstruction of extinct forms. For this study, the scapula of *Papio hamadryas* (n=27), *Hylobates lar* (n=53), *Pongo* sp. (n=19), *Gorilla gorilla* (n=39), *Pan troglodytes* (n=41), and *Homo sapiens* (n=81) of the collection of the Anthropological Institute in Zurich was analyzed and compared to that of DIK 1-1 (*A. afarensis*, pictures) and to casts of the scapula of Sts 7 (*A. africanus*), MH2 (*A. sediba*), and KNM WT 15000 (*H. erectus*). A number of landmarks were defined on the scapula according to Martin and Saller (1957) and digitized with a MicroScribe-3DX. Based on these data, the scapular index, supra- and infraspinous indices, and the axilloglenoid angle have been calculated in order to enable comparison with older studies. Our results show that the upwards pointing glenoid of *Australopithecus sediba* is significantly different from that of humans, which points more laterally. Therefore, the axilloglenoid angle rather resembles the other species of *Australopithecus* and falls into the range of great apes, suggesting an adaptation to climbing. But the scapula is also wider than long with a very broad infraspinous fossa and an intermediate breadth of the supraspinous fossa as adaptation to a very wide range of movements that we also find in *Homo* and *Pongo*. In comparison with *Homo erectus* we again see a scapula that is wider than long with a high axilloglenoid angle resembling that of modern humans.

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## New Insights into the Stratigraphy and Archaeology of the Late Oldowan and Early Acheulean at Olduvai Gorge, Tanzania

Lindsay J. McHenry, *Department of Geosciences, University of Wisconsin-Milwaukee, USA*  
Ignacio de la Torre, *Institute of Archaeology, University College London, UNITED KINGDOM*  
Michael C. Pante, *Institute of Archaeology, University College London, UNITED KINGDOM*  
Jackson K. Njau, *Department of Geosciences, Indiana University, USA*

In recent years, archaeological objectives of the Olduvai Geochronology and Archaeology Project (OGAP) have targeted Middle Bed II deposits, the interval in which the change from the Oldowan to the Acheulean seems to have taken place at Olduvai. Excavations at HWKEE have unveiled a large stone tool assemblage with no handaxes, and a test trench in MNK Skull Site has yet to produce any Acheulean-like material. Higher up in the sequence, handaxes have been found in stratigraphy at EFHR and MNK Main, while in FC West handaxes were collected on surface but are yet to be documented *in situ*. Preliminary results for the taphonomy of two sites (HWK EE and EFHR) suggest hominins, mammalian carnivores, crocodiles, and fluvial processes contributed to their complex formational histories. Both sites preserve feeding traces found on the bones of large mammals including those left by hominins in the form of stone tool butchery marks inflicted during the disarticulation and/or defleshing of carcasses, and hammerstone percussion marks resulting from the exploitation of the marrow from within limb bones. Further analysis of these traces has the potential to reveal the nature of hominin feeding behavior and their ecological interactions with carnivores at the sites. Detailed stratigraphic research near excavated sites has confirmed Hay's (1976) stratigraphic placement of MNK Main (through the new identification of *in situ* Bird Print Tuff (BPT) directly below the Upper Augitic Sandstone), but calls into question the previously inferred Middle Bed II position of EFHR (based on position relative to the putative Tuff IIC stratigraphic interval and Tuff IID). HWKEE remains firmly placed within the Lower Augitic Sandstone that locally cuts into Tuff IIA, though overlying BPT is locally cut out. Further detailed geochronological and stratigraphic research will continue to improve this framework and constrain the earliest Acheulean occurrences at Olduvai.

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### References Cited:

Hay, R.L. 1976. *Geology of the Olduvai Gorge: A Study of Sedimentation in a Semiarid Basin*. University of California Press, New York, 203 pp.

## Cut Mark Cluster Geometry Does Not Predict Oldowan Stone Tool Type or the Amount of Muscle Tissue Defleshed

Stephen R. Merritt, *Anthropology, University of Alabama at Birmingham, USA*

Oldowan hominins' butchery behavior creates cut marks on mammalian skeletal specimens as decisions about flake or core tool utility and which musculo-skeletal tissues to butcher are enacted. Traditionally, clusters of relatively long cut marks organized into parallel sets were assigned to flake tools, whereas densely packed clusters of short cut marks in scattered geometric orientation were interpreted as core tool use (Toth 1985, de Juana et al. 2010). Likewise, filleting large muscle packages from limb bones was suggested to leave long, parallel clusters of cut marks, whereas defleshing smaller muscle scraps near their skeletal origin is thought to produce dense clusters of short cut marks (Bunn 1994). The actualistic experiments reported here investigate the connection between cut mark cluster geometry, Oldowan tool type, and the amount of muscle defleshed. An experienced butcher used a single replicated Oldowan tool per trial to deflesh one domestic goat or cow half-carcass. Carcass size, tool type, and flesh amount were evenly distributed across 16 trials. Cut mark clusters were molded with dental putty and photographed. Clusters of defleshing cut marks are defined as series of striae with parallel, sub-parallel, or intersecting orientation, and are spatially distinct from other clusters of marks on a skeletal portion. Median cut mark length, standard deviation of cut mark length and angle, and the area within the perimeter of cut mark end points were measured for each cluster. The results indicate that cut mark attributes on near epiphyseal and midshaft bone portions vary little across tool type or with the amount of tissue defleshed, and cut mark length and angle variability is related to increasing cut mark count and cluster area. This equifinality does not support a quantitative model of cut mark geometry that reliably distinguishes flake vs. core butchery or bulk vs. scrap defleshing cut mark clusters.

### References Cited:

- Bunn, H.T. 1994. Early Pleistocene hominid foraging strategies along the ancestral Omo River at Koobi Fora, Kenya. *Journal of Human Evolution* 27: 247–266.
- de Juana, S., Galan, A.B., and Dominguez-Rodrigo, M. 2010. Taphonomic identification of cut marks made with lithic handaxes: an experimental study. *Journal of Archaeological Science* 37: 1841–1850.
- Toth, N. 1985. The Oldowan reassessed: a close look at early stone age artifacts. *Journal of Archaeological Science* 12: 101–120.

## The Functional Morphology of the Hominid Fibula

Sabrina Meyer, *Anthropological Institute and Museum, University of Zurich, SWITZERLAND; and, Centre for Evolutionary Medicine, Institute of Anatomy, University of Zurich, SWITZERLAND*

Peter Schmid, *Anthropological Institute and Museum, University of Zurich, SWITZERLAND*

In the past, the fibula has often been neglected in comparative studies due to the scarcity in the fossil hominid record. In fact, only two early hominid fibulae shafts are known, Stw 356 (*Australopithecus africanus*) from Sterkfontein, South Africa, and OH 35 (*Homo habilis*) from Olduvai Gorge, Tanzania. Functionally, the fibula is little involved in weight support. Yet, it serves as an important origin for muscles of the lower leg. The aim of this study was to analyze differences in the origin and insertion of m. peroneus longus in primates to obtain new insights into the evolution of the hominid foot. We compared the morphology of the Stw 356 fibula and of a cast of OH 35 to the fibulae of *Homo sapiens*, *Pan troglodytes*, *Pongo pygmaeus*, and *Macaca mulatta* from the Collection of the Anthropological Institute of the University of Zurich. In addition, the lower leg and foot of one chimpanzee, one orangutan, and one macaque were dissected and the dry weight and functional anatomy of the muscles were studied. Our results show no significant differences in origin, insertion, gross morphology and weight proportion of m. peroneus longus in the analyzed non-human primate specimens. The end tendon of m. flexor digitorum fibularis was lacking in *Pongo*. This might be related to the reduction of the hallux in orangutans and needs further study. The morphology of the fibular shafts of Stw 356 and OH 35 falls within the human range. The results of this study will add to the ongoing debate whether australopithecines and early *Homo* possessed human-like feet with adducted great toes or ape-like feet with medially diverged, mobile halluces.

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## Towards a New Methodology of Lithic Residue Analysis

Gilliane Monnier, *Anthropology, University of Minnesota, USA*

One of the great puzzles of Paleolithic archaeology today remains the interpretation of stone tool functions. While lithic usewear studies have attempted to address this issue, they largely remain plagued by an inability to quantify microwear. Residue analysis has emerged as an alternative, and often complementary, means of analyzing stone tool functions based upon the identification of microresidues on stone tools. However, most of these studies are currently based upon morphological identifications using visible light microscopy (VLM) alone. These studies, like usewear studies' interpretations of microwear traces, have been unable to develop objective means of characterizing microresidues. There is, in fact, a large degree of unacknowledged ambiguity in the morphological interpretation of microresidues (Monnier et al. 2012). Here I report the development of a new methodology of lithic residue analysis. I argue that it is essential to use multiple imaging techniques, as well as chemical analytical techniques, in order to provide objective and quantifiable means of identifying residues. I present data from a case study involving three Mousterian artifacts recently excavated from the

site of Hummal, Syria (Le Tensorer et al. 2007; Hauck 2011). I systematically study the microresidues on these artifacts using VLM, scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), Fourier-Transform Infrared Microscopy (FTIR-M), and confocal Raman microscopy. My results confirm that many of the residues on these tools are bitumen, which was likely used as a hafting adhesive. Other residues are authigenically formed minerals. While earlier studies have identified bitumen residues using GC-MS (Boëda et al. 2008), this destructive method requires removal of large amounts of residue. The multi-analytical methodology I propose, on the other hand, is non-destructive and provides an objective means of characterizing residues on stone tools.

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**References Cited:**

- Boëda, É., Bonilauri, S., Connan, J., Jarvie, D., Mercier, N., Tobey, M. et al. 2008. New evidence for significant use of bitumen in Middle Paleolithic technical systems at Umm el Tlel (Syria) around 70,000 BP. *Paléorient* 34(2), 67–83.
- Hauck, T.C. 2011. Mousterian technology and settlement dynamics in the site of Hummal (Syria). *Journal of Human Evolution* 61(5), 519–537.
- Le Tensorer, J., Jagher, R., Rentzel, P., Hauck, T., Ismail-Meyer, K., Puempin, C. et al. 2007. Long-term site formation processes at the natural springs Nadaouiye and Hummal in the El Kowm oasis, central Syria. *Gearchaeology* 22(6), 621–639.
- Monnier, G. F., Ladwig, J.L., and Porter, S.T. 2012. Swept under the rug: The problem of unacknowledged ambiguity in lithic residue identification. *Journal of Archaeological Science* 39(10), 3284–3300.

## Can Ungulate Assemblages Be Used to Detect Rapid Climatic Changes? Implications of a New Time Series for the Chronology of the Mousterian

Eugène Morin, *Anthropology, Trent University, CANADA*

The study of marine and ice core data has led to the discovery of numerous high-amplitude climatic oscillations during the last glacial period. These oscillations often resulted in marked changes (>5-10°) in temperature in western Europe, especially during the warm Dansgaard-Oeschger and cold Heinrich events. The discovery of these rapid oscillations suggests that the impact of climatic variations may have been significantly underestimated in previous reconstructions of continental environments, including those produced by archaeologists. Until recently, it was unclear whether archaeological sequences possessed sufficient resolution to allow the detection of these centennial- to millennial-scale changes in climatic conditions. Here I examine this issue in a small region of southwest France using a composite, roughly continuous, time series. This series, which focuses on variations in the relative abundance of reindeer (*Rangifer tarandus*) as a proxy for temperature, is long and covers most of Marine Isotope Stage (MIS) 5b to the beginning of MIS 1. The composite time series shows several trends. Most striking among these is the fit observed between fluctuations in reindeer representation in southwest France and variations in the relative abundance of cold-water foraminifera in the North Atlantic. These strong correlations suggest that variations in reindeer representation in the time series were coupled with Heinrich and Dansgaard-Oeschger events. This last observation is particularly significant because this seems to be the first dataset to find support for such a relationship in ungulate assemblages. Because Heinrich and Dansgaard-Oeschger events have been anchored into an absolute chronology, these results have wider implications as they can be used to revisit the chronology of the Mousterian of France.

## Long-Term Dietary and Settlement Change at the Paleolithic Occupation of Franchthi Cave, Greece (39,000–4,000 cal BP)

Natalie Munro, *Anthropology, University of Connecticut, USA*  
 Mary Stiner, *School of Anthropology, University of Arizona, USA*

This presentation examines human diet and settlement evolution at the multicomponent site of Franchthi Cave (39,000–4,000 cal BP) located on the Argolid Peninsula of the Greek Peloponnese. The cave's long occupational sequence offers a rare opportunity to reconstruct long-term evolutionary change in human diet and settlement strategies in relation to dramatic shoreline and environmental changes. The cultural deposits in Franchthi represent Aurignacian, Gravettian, Epigravettian, Mesolithic, and Neolithic cultural phases, and they span major climatic events including the Last Glacial Maximum and the Younger Dryas. This paper investigates human diet and site function using zooarchaeological methods and focuses on human hunting strategies, the overall character of the meat diet, and waste disposal patterns on site. The zooarchaeological data indicate that shifts in human diet were not simply temporary adjustments to local environmental conditions. The observed expansions in dietary breadth and other behaviors reflect the evolution of new foraging systems. The trend begins with diversification in the range of small terrestrial animals exploited, followed by increasing emphasis on marine foraging and fishing. The trend in aquatic exploitation indicates a steady increase in foraging expenditures, beginning with shoreline collecting and culminating in the exploitation of large tunny. Corresponding shifts in ungulate mortality patterns indicate that hunters captured higher proportions of juvenile red deer and wild ass with time, and that they transported body-parts with reduced utility. These dietary changes were accompanied by significant shifts in human settlement patterns, including a gradual intensification in site use, characterized by increased rates of deposition and more frequent hearth building.

## Preliminary Radiographic Analysis of Neandertal and Holocene Human MC1 Opponens Crests

Wesley Niewoehner, *Anthropology, California State University San Bernardino, USA*

Neandertal first metacarpals (MC1s) are remarkable for their large opponens pollicis insertion which is described as a fin-like (Vlček 1975) or a flange-like (Trinkaus 2006, 2007) radially projecting ridge. It is argued that Neandertals exhibit the derived form of the opponens insertion while all Late Pleistocene and Holocene modern humans, except Sunghir 1, exhibit the ancestral pattern of a variably expressed, non-flange-like opponens crest. The flange-like opponens insertion on Sunghir 1 is presented as one (but not the only) example of evidence for Neandertal admixture (Trinkaus 2007, 2007). In fact, the Neandertal flange morphology is not invariant and two other European early moderns, Parabita and Grotte des Enfants 4, have flange-like opponens crests. Projecting flange-like opponens crests, though rare, are also present on some Holocene human MC1s, suggesting the possibility that developmental plasticity, rather than Neandertal admixture is responsible for this variation. This preliminary analysis uses both uniplanar x-rays and CT scans to determine whether Neandertal and recent human opponens crest morphologies are distinguishable from each other radiographically. Six Holocene human MC1s were chosen for their degree of crest development which ranges from barely discernible to a Neandertal-like radially projecting ridge. These are compared to Neandertal MC1s from Tabun 1, La-Chapelle-aux-Saints, Kebara 2, La Ferrassie 2, and Amud 1. In both groups the MC1 cortical bone thickness remains approximately constant along the entire ulnar aspect of the diaphysis. Also, in both groups the radial side of the diaphysis exhibits thick cortical bone proximal to the crest but is thinned along the crest's edge. This morphology is consistent regardless of the degree of the crest's projection. Therefore, the opponens crest on both Neandertal and Holocene human MC1s is not solid bone. The crest is a dorsopalmarly flat and radially projecting portion of the diaphysis that is sparsely filled with trabecular bone.

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### References Cited:

- Trinkaus, E. 2006. Modern Human versus Neandertal Evolutionary Distinctiveness. *Current Anthropology* 47(4), 597–620.  
 Trinkaus, E. 2007. European Early Modern Humans and the Fate of the Neandertals. *Proceedings of the National Academy of Sciences USA* 104(18), 7367–7372.  
 Vlček, E. 1975. Morphology of the first metacarpal of neandertal individuals from the Crimea. *Bulletins et Mémoires de la Société d'anthropologie de Paris*, XIII<sup>e</sup> Série, tome 2, fascicule 3, 257–276.

## Neanderthal and Modern Human Adaptations in Climatic Context: New Fieldwork in Western Ukraine

Philip R. Nigst, *Division of Archaeology, Department of Archaeology and Anthropology, University of Cambridge, UNITED KINGDOM, Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, GERMANY*

Larissa Koulakovska, *Archaeological Museum, Institute of Archaeology, National Academy of Sciences of Ukraine, Kiev, UKRAINE*

Vitaly Usik, *Archaeological Museum, Institute of Archaeology, National Academy of Sciences of Ukraine, Kiev, UKRAINE*

Freddy Damblon, *Department of Palaeontology, Royal Belgian Institute of Natural Sciences, Brussels, BELGIUM*

Jean-Jacques Hublin, *Department of Human Evolution, Max-Planck-Institute for Evolutionary Anthropology, Leipzig, GERMANY*

Paul Haesaerts, *Department of Palaeontology, Royal Belgian Institute of Natural Sciences, Brussels, BELGIUM*

Neanderthal and modern human adaptations to various climatic conditions are a heavily debated issue in the paleoanthropological community. In order to contribute to a better understanding of these adaptations during roughly MIS 5 to 2, we recently started an interdisciplinary research project in Western Ukraine. The region was selected for its rich archaeological record and the thick loess deposits with a high paleoclimatic resolution. Since 2010 we have been conducting surveys and test-excavations in two areas—the Middle Dniestr Valley (east of the Carpathian Mountains) and the Transcarpathian Ukraine (on the border with Hungary). The goals of our work include: (1) study of site formation processes, (2) reconstruction of environment and climate; and, (3) analyzing lithic and faunal assemblages. This poster will present first results of our survey in the Middle Dniestr valley and of the excavations at Beregovó I (Transcarpathian Ukraine). In the Middle Dniestr valley (around the well-known sites of Molodova) we are surveying new, vertical exposures created by the changing water table of the Dniestr reservoir; this ensures that all our discoveries are stratified and samples for dating, cultural attribution, and environmental reconstruction can be collected from vertical sections. The 2012 fieldwork resulted in new Middle and Upper Paleolithic sites. Here we focus on the Middle Paleolithic site of Neporotovo 7, stratigraphically located below the MIS 5 soil complex, and on the Upper Paleolithic site of Korman 9. Excavations at Beregovó I provided a rich Proto-Aurignacian assemblage, including abundant retouched bladelets (e.g., Dufour bladelets subtype Dufour). Refitted sequences point towards several different reduction sequences for bladelet production. First <sup>14</sup>C dates and environmental data are also presented. This is the first well stratified open-air Proto-Aurignacian site in Central Europe. All archaeological occurrences are located in well-stratified loess-paleosol sequences providing a high-resolution climatic context for the Neanderthal and modern human occupations.

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## Diets of Sympatric Great Apes and Fossil Hominins: Searching for Isotopic Analogies

Vicky M. Oelze, *Department of Primatology, Max Planck Institute for evolutionary Anthropology, GERMANY*  
 Josephine Head, *Department of Primatology, Max Planck Institute for evolutionary Anthropology, GERMANY*  
 Martha Robbins, *Department of Primatology, Max Planck Institute for evolutionary Anthropology, GERMANY*  
 Michael Richards, *Department of Anthropology, University of British Columbia, CANADA*  
 Christophe Boesch, *Department of Primatology, Max Planck Institute for evolutionary Anthropology, GERMANY*

In fossil hominins, several major dietary adaptations have been revealed by stable carbon isotope analysis—one specialized to savanna habitats with high levels of C<sub>4</sub>-plants as seen in *Australopithecus bosei*, another more opportunistic feeding strategy with mixed diets (*Au. africanus*, *Au. anamensis*), and a third adaptation probably resembling the folivorous and frugivorous C<sub>3</sub>-plant diets of great apes living in Africa today (*Au. ramidus*, *Au. sediba*) (summarized by Ungar and Sponheimer 2011). It appears that Pleistocene hominins may have had diets more similar to those of extant great apes than previously considered, as the gradient between the mixed and the purely C<sub>3</sub>-plant diets may come into question if the data are corrected for diet-enamel offsets (Schoeninger et al. 2012). Thus, carbon isotope ratios measured in ape tissues may indeed be used as a proxy for paleoanthropological reconstructions of habitat and niche differentiation in sympatrically living hominins. Here, we present the first carbon isotope data of two sympatrically living African great apes (*Gorilla gorilla gorilla* and *Pan troglodytes troglodytes*), which reflects their diverging feeding adaptations. Within a C<sub>3</sub>-based habitat, we can differentiate between the diet of chimpanzees depending mainly on fruits and the consumption of higher proportions of herbaceous vegetation by gorillas. Although the studied habitat undergoes pronounced seasonal shifts in rainfall and food availability, temporal isotopic variation in both ape taxa is moderate and does not resemble the inter-individual variation observed in fossil hominin enamel. Thus, the high degree of dietary opportunism assumed for several australopithecine species may be supported by our preliminary data.

### References Cited:

Schoeninger et al. 2012. Diets of early hominins: Alternative hypothesis for the isotope data. Paleoanthropological Society Meetings 2012, Memphis, Tennessee. *PaleoAnthropology* 2012: A31.

Ungar P.S. and Sponheimer, M. 2011. The Diets of Early Hominins. *Science* 334(6053): 190–193.

## Investigating Hominin Paleohabitats Using Fossil Rodent Ecomorphology

Oliver Paine, *Anthropology, University of Colorado Boulder, USA*  
 Jennifer Leichter, *Anthropology, University of Colorado Boulder, USA*  
 Matt Sponheimer, *Anthropology, University of Colorado Boulder, USA*  
 Nico Avenant, *Mammalogy, National Museum Bloemfontein, SOUTH AFRICA*

The taxonomic composition of fossil rodent assemblages from hominin sites can be used to infer paleohabitat structure. However, much of the fossil rodent material recovered is non-diagnostic or too incomplete to allow reliable taxonomic assessment, as is the case with the abundance of isolated fossil incisors that often confronts researchers. Thus, an ecomorphological, taxon-free method of investigating fossil rodent habitats would greatly augment our ability to utilize rodents for paleoenvironmental reconstruction. Croft et al. (2011) outline methods by which upper incisor morphology can be used to predict dietary preferences among caviomorph rodents. Using these methods, we have demonstrated that extant South African rodents can also be successfully partitioned into distinct ecomorphological categories. Because South African rodent species have remained relatively stable over the past 5 My, there is great potential in applying these methods to fossil assemblages. However, their application to the fossil material becomes more difficult because the necessary morphometric measurements require that the incisor be positioned correctly within its alveolus. Due to diagenesis and the inherent fragility of fossil rodent crania, this positioning can rarely be determined even when the fossil incisor is still articulated with the premaxilla. To better the applicability of such ecomorphological approaches we have been developing new measurements specific to isolated incisors. Here we discuss these methods and their utility with fossil rodent material from Sterkfontein, Swartkrans, and Kromdraai.

### References Cited:

Croft, D.A., Niemi, K., and Franco, A. 2011. Incisor morphology reflects diet in caviomorph rodents. *Journal of Mammalogy* 92, 871–879.

## A GIS Image Analysis Approach to Oldowan Hominin Meat Eating at Kanjera South, Kenya

Jennifer A. Parkinson, *Department of Anthropology, CUNY Graduate Center & NYCEP, USA*  
 Thomas W. Plummer, *Department of Anthropology, Queens College, CUNY & NYCEP, USA*

The shift to increased meat consumption may be one of the major adaptive changes in hominin dietary evolution. Meat-eating by hominins is well documented at Plio-Pleistocene archaeological sites in East Africa by butchery marks on bones. While it is established that Oldowan hominins butchered large mammal carcasses, the method of carcass acquisition (i.e., hunting vs. scavenging) and degree of completeness (fleshed vs. defleshed) is less certain. Our study addresses these questions through an analysis of bone modification

patterns created by hominins and carnivores in the ca. 2.0 Ma zooarcheological assemblage from Kanjera South, Kenya. We argue that the Kanjera assemblage offers some of the earliest clear evidence of routine butchery of large mammal carcasses by early members of the genus *Homo*, in concordance with the findings of Ferraro (2007). We used GIS to record bone preservation in the Kanjera assemblage as well as in several modern, experimentally-modified bone assemblages, which we use for comparison. We documented the placement of hominin- and carnivore-induced modifications on bones from these assemblages, and with the GIS Spatial Analyst, we identified where particular types of modifications clustered. Results show that the pattern of bone preservation at Kanjera is similar to GIS-generated models based on experimental bone assemblages that were first butchered and hammerstone fractured by humans, and subsequently scavenged by carnivores. The distribution of bone modifications on the Kanjera fauna also suggests hominins had early access to small bovids. Butchery marks appear almost exclusively in “hot zones” (Domínguez-Rodrigo and Barba 2007)—areas where flesh never survives lion consumption—further suggesting hominins at Kanjera were not scavenging carnivore kills. Overall frequencies of both hominin and carnivore modifications are lower than those at the slightly younger site of FLK Zinj (Olduvai Gorge, Tanzania), suggesting differing competitive regimes at the two sites.

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**References Cited:**

Domínguez-Rodrigo, M. and Barba, R. 2007. The behavioral meaning of cut marks at the FLK Zinj level: the carnivore-hominid-carnivore hypothesis falsified (II). In *Deconstructing Olduvai: A taphonomic study of the Bed I sites*, M. Domínguez-Rodrigo, C.P. Egeland, and R. Barba (eds.), pp. 75–100, New York: Springer.

Ferraro, J.V. 2007. *Broken bones and shattered stones: on the foraging ecology of Oldowan hominins*. PhD dissertation. University of California-Los Angeles, Los Angeles, California.

## The Palaeodeserts Project: Environmental Change and Hominin Occupation in the Arabian Peninsula

Michael D. Petraglia, *School of Archaeology, University of Oxford, UNITED KINGDOM*  
 Abdullah Alsharekh, *School of Archaeology, King Saud University, SAUDI ARABIA*  
 Remy Crassard, *Maison de l’Orient et de la Méditerranée, CNRS, FRANCE*  
 Huw S. Groucutt, *School of Archaeology, University of Oxford, UNITED KINGDOM*  
 Ceri Shipton, *School of Social Science, University of Queensland, AUSTRALIA*  
 Adrian Parker, *Department of Anthropology and Geography, Oxford Brookes University, UNITED KINGDOM*  
 Ash Parton, *Department of Anthropology and Geography, Oxford Brookes University, UNITED KINGDOM*  
 Nick Drake, *Department of Geography, King’s College London, UNITED KINGDOM*  
 Paul Breeze, *Department of Geography, King’s College London, UNITED KINGDOM*  
 Richard Jennings, *Department of Archaeology, University College Cork, IRELAND*

The Arabian peninsula is a key region for understanding population interactions between Africa and the rest of Eurasia. The Palaeodeserts Project is a new five year initiative to study Middle Pleistocene, Late Pleistocene, and Early Holocene localities in Arabia, with an aim to examine the influence of climate change on the distribution and survival of animal and hominin populations. Acheulean sites are widely distributed, indicating use of the Red Sea coastal zone and the interior of the peninsula. Recent technological analysis of Acheulean assemblages provides information about stone tool procurement, manufacturing techniques, and resultant tool forms. Several excavations have recently been conducted on Middle Paleolithic localities across the peninsula, indicating hominin occupations during the humid periods of MIS 7, MIS 5 and MIS 3. The diversity of lithic assemblages appears to signal variations in population history and geographic relations. Paleohydrological mapping indicates the use of riverine and lacustrine settings, and suggests different routes for the movement of hominin populations. We discuss key findings from recent interdisciplinary fieldwork, examining how cycles of wetting and drying throughout the Pleistocene influenced hominin paleodemography.

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## U-Pb Dating Cave Carbonates: A New Chronometer for the South African Hominin Cave Sites

Robyn Pickering, *School of Earth Sciences, University of Melbourne, AUSTRALIA*

South Africa has a rich early hominin fossil record, concentrated mainly in cave deposits, which, until recently, have been sparsely dated and often considered the poor cousin of the vast, well dated deposits of East Africa. Recent advances in U-Pb dating of carbonates (mostly cave carbonates or speleothems, particularly flowstones) are beginning to change this. Flowstones layers sandwiched between fossil bearing sediments can be treated as chronostratigraphic marker horizons and play an analogous role to the volcanic tuffs in East Africa. The key to successful U-Pb dating is isolating uranium rich horizons within the flowstones, making careful sample pre-screening a necessity. Most U-Pb dating work has focused on the ‘Cradle of Humankind’ caves, where ages can now be assigned to at least four of the early hominin species. Ages can be further refined by investigating the paleomagnetic signals preserved in the sediments and flowstones. Flowstones from caves several kilometres apart have U-Pb ages within error of each other, suggesting some large scale cyclicity behind the alternating deposition of flowstone and cave sediment. U-Pb dating has also been successfully applied to the southern Cape coastal cave sites of Pinnacle Points and to small buried stalagmites from the archaeological deposits at Wonderwerk Cave. Attempts to date calcrete horizons from the western Cape coast are underway.

**Acknowledgements:** Thanks to Jon Woodhead and the Uni Melb Isotope lab team. My work would not be possible without the support of many: Andy Herries, Dave Braun, Lee Berger, Paul Dirks, Julia Lee-Thorp, Curtis Marean, Mira Bar-Matthews, and Kaye Reed.

## The Relationship Between Aerobic Activity and Brain Size During Hominin Evolution

John D. Polk, *Anthropology, University of Illinois Urbana Champaign, USA*  
David A. Raichlen, *Anthropology, University of Arizona, USA*

Explaining brain size increases in human evolution is fundamental to our understanding of human uniqueness, and it is clear that human brain size evolution has been influenced by many factors. Previous explanations have suggested adaptive scenarios favoring specific cognitive abilities, through improved diet quality and increased sociality, among others. Here we propose a novel evolutionary and developmental mechanism relating increased aerobic capacity to increased brain size in human evolution. This mechanism is supported by a broad interdisciplinary array of data. Mouse models, as well as samples of juvenile and aged humans have shown that aerobic exercise increases the size of brain components, improves specific cognitive abilities, and is protective against cognitive declines. Rodent studies have identified the developmental mechanisms underlying these neurological effects indicating that they are mediated by neurotrophins and growth factors (VEGF, IGF and BDNF). Artificial selection experiments, favoring either voluntary wheel running or aerobic capacity, have demonstrated increased baseline levels of these growth factors, and corresponding increases in brain components. Comparative data show a relationship between aerobic capacity and brain size across mammals. Finally, quantitative genetic studies have shown that selection on locomotor variables explains differences in hominin lower extremity morphology, and comparative studies have argued for increased endurance activity. Combining this wealth of data, we argue that selection for hominin locomotor performance resulted in increased baseline levels of growth factors. During gestation and development, these increased growth factors led to the increased brain growth characteristic of our species. This model suggests that some component of brain size evolution was a byproduct of selection acting on non-cognitive factors. Although we do not argue that aerobic activity explains all of human brain evolution, we believe a focus on both cognitive and non-cognitive selection pressures may help us understand the complex evolutionary processes that led to the human brain.

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## Wetter-Drier-Wetter: The Effect of Environmental Oscillations on Avifaunal Communities and Hominin Subsistence Strategies at Olduvai Gorge

Kari Prassack, *Hagerman Fossil Beds National Monument, National Park Service, Department of the Interior, USA*

Olduvai's avifaunal communities support numerous previous studies identifying cyclical wet-dry environmental shifts between Lower Bed I and Lowermost Bed II times (between Tuffs IA and IIA, ~1.88–1.72Ma). The Lower Bed I community is comprised of lake and wetland birds. This shifts to a mixed-habitat community with shore, wetland, bush and woodland taxa during Middle and Upper Bed I. A return to wetter conditions, with a lake and wetland-dominated avifauna, occurs during Lowermost Bed II. What does this mean for hominin subsistence? Wetter climates, with associated higher lake stands and/or extensive wetlands (Lower Bed I and Lowermost Bed II), would have provided a range of possible food items, including wetland plant roots and stalks, birds, eggs, turtles, and crustaceans. The utilization of these resources would have produced weak signals of hominin activities (i.e., low incidence of cut-marked large mammal bone). Cut-marked bones, and to a lesser extent stone tool discard, may not act as reliable indicators of hominin activities during wetter periods. Resources on more arid landscapes (Middle and Upper Bed I) would have been patchier, with hominin activities centered near watering holes. There, scavenging of large mammal carcasses would have produced a strong, centralized hominin subsistence signal. Cut-marked mammal bones accumulated during arid periods (e.g., at FLK 22) may artificially inflate the overall importance of large mammal carcasses to Plio-Pleistocene hominin subsistence strategies. The Olduvai birds support that climatic-induced environmental oscillations led to increased aridity during Middle and Upper Bed I and that this would have affected patterns of hominin subsistence, especially that readily identifiable in the archaeological record. Testable, holistic models of hominin food procurement and diet that go beyond the hominin scavenging debate are needed.

## The Implications of Variation in Late Pleistocene Levantine Crania for Understanding the Pattern of Human Evolution

Davorka Radovic, *Department of Geology and Paleontology, Croatian Natural History Museum, CROATIA*

This paper examines the variability in a sample of Late Pleistocene fossil human crania found in the Southern Levant, in present day Israel. This sample (n=13) is comprised of both Neandertals from Tabun and Amud, and the remains from Skhul and Qafzeh that are considered predecessors of modern humans. Many authors describe the heterogeneity of the Levantine sample as unusual, greater than what modern populations could be expected to exhibit, and many believe they represent groups of different human species. This study focuses on whether the magnitude of Levantine variation is really unusual. To demonstrate the Levantine sample variation is really caused by taxonomic differences, the Levantines should, at the minimum, exhibit a greater magnitude of variation than expected

in a comparable modern population of mixed ancestry from a confined geographic area and limited time span. Smaller magnitude of variation would indicate that the Levantine variation is not from species mixture; it involved a mixture of human populations. The issue is addressed in a statistical, comparative context. The null hypothesis is tested by comparing the Levant sample's non-metric cranial variation with the cranial variation in 100 mixed-ancestry medieval crania from the Pannonian Plain (fourth to eighth century A.D.). Dichotomous, binomial responses were collected for 67 traits. The fossil Levantine sample was compared to the resampled Pannonian distribution to test whether the magnitude and variance of the Levant data are expected within it. The results show that the magnitude of the variation in the Levantine sample is not unusual when compared to the Pannonian sample, and the null hypothesis of admixture of different populations cannot be refuted. These results are strongly supported by the recent ongoing advances in the study of ancient and modern nDNA.

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## Contributions of Morphology and Posture to the Evolution of Energetically Economical Hominin Bipedalism

David Raichlen, *Anthropology, University of Arizona, USA*  
 Adam Foster, *Anthropology, University of Arizona, USA*  
 James Webber, *Anthropology, University of Arizona, USA*  
 Herman Pontzer, *Anthropology, Hunter College, USA*

Researchers have long debated the importance of energetics in the evolution of human bipedalism. Comparisons with great apes can tell us much about the links between anatomy, joint postures, and energy costs, improving interpretations of fossil hominin morphology from an energetics perspective. For example, recent work shows that chimpanzees use more energy during walking than humans, suggesting that chimpanzee-like anatomy or walking mechanics in the earliest hominins may have come with an energy cost. Here, we experimentally altered gait in a sample of humans (n=8) to determine how much of the difference in energy costs between chimpanzees and humans can be attributed to posture alone. We compared energy costs measured via oxygen consumption, as well as costs estimated using inverse dynamics, in humans walking in four different postures: 1) normal, 2) bent-hip bent-knee, 3) bent back (trunk pitched forward with extended knee); and, 4) bent-hip bent-knee bent-back (most chimpanzee-like). We found that, although energy costs were higher in humans walking with experimentally altered gaits (RM ANOVA  $p < 0.0001$ ), energy expenditures in these gaits did not reach the high costs of chimpanzee locomotion ( $p < 0.001$ ). Within the human sample, the most chimpanzee-like gait (bent back with flexed knee and hip) led to the highest energy costs and the highest active muscle volumes, highlighting the energetic significance of an erect trunk posture along with more extended hindlimbs in normal human walking. We show that much of the remaining difference in energy cost between taxa is due to soft tissue differences (longer muscle fascicles contributing to large active muscle volumes in chimpanzees). These results suggest that anatomical adaptations that allow extension of the knee, hip, and back, while important, were not enough to generate economical bipedal walking. Generally neglected changes in soft tissue anatomy were equally important during human evolution.

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## The Middle Stone Age of Southeastern Tanzania: Results from Archaeological Survey

Kathryn Ranhorn, *Anthropology, The George Washington University, USA*  
 Alison Brooks, *Anthropology, The George Washington University, USA*  
 Fidelis Masao, *Archaeology, University of Dar es Salaam, TANZANIA*  
 John Yellen, *National Science Foundation, USA*

The origin and spread of modern humans in Africa remains a central question in paleoanthropology today. The Middle Stone Age (MSA), during which modern human behavior emerged, is well documented in South Africa as well as in Kenya, Ethiopia, and parts of northern Tanzania. The intermediate region between southern and eastern Africa, however, remains largely unexplored. Current MSA sites are recorded at Magubike, Mumba, Nasera, and other rock shelters in Tanzania, the Ndutu Beds at Olduvai Gorge, as well as Karonga, Malawi, and in the Lake Niassa region of northern Mozambique. Southeastern Tanzania however, containing woodland environments paralleling those of central/southern Africa rather than the Rift Valley and highland regions further north, is lacking in published MSA sites. Archaeological survey conducted during the 2012 field season recorded 10 MSA sites in the Mtwara, Lindi, and Ruvuma districts of Tanzania near the border with Mozambique, including nine open air sites and one rock shelter. The sites discussed here mainly cluster approximately 100km inland; however, a new area further west near Tunduru also was explored. The predominantly flake-based assemblages include single- and multi-platform cores including classic Levallois cores, a micro-blade core, flake blades, and scrapers, mostly of quartzite and chert. MSA materials were commonly found in association with quartzite outcrops or near channel margins. Acheulian large cutting tools were absent and Later Stone Age artifacts were extremely rare, suggesting that the largest Pleistocene populations lived during the MSA.

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## Revisiting the Middle to Upper Paleolithic transition at Gatzarria Cave

Elspeth Ready, *Anthropology, Stanford University, USA*  
Eugène Morin, *Anthropology, Trent University, CANADA*

Gatzarria Cave, located in the French Basque country, contains a critical sequence spanning the Middle to Upper Paleolithic transition, including Mousterian, Châtelperronian, and multiple Proto-Aurignacian and Aurignacian levels. Because this sequence may have important implications for understanding the process of modern human expansion into Europe, its analysis must be based on a robust taphonomic evaluation. In this paper, we present issues regarding excavation procedures and post-excavation sorting at the site, which were brought to our attention during an in-depth study of faunal remains from the Middle Ensemble, the stratigraphic group which includes the Middle to Upper Paleolithic transition deposits. This information calls into question analyses based on the published stratigraphic attributions for the site. In response to this discovery, we reanalyzed a subsample of lithic data from the Middle Ensemble in order to better understand the spatial distribution of Middle and Upper Paleolithic artifacts. Despite the presence of potential zones of disturbance, we demonstrate that in some portions of the cave, stratigraphic mixing of Middle and Upper Paleolithic artifacts is limited and careful analysis of the associated assemblages should allow insight into Neandertal and modern human behaviors at the site. Moreover, to improve our understanding of the site's chronology, we present the first AMS radiocarbon dates for faunal remains from the most recent Mousterian levels. In sum, this site retains great importance for understanding the Neandertal to modern human transition at the frontier of the Iberian peninsula, provided that future analyses are based on a detailed reanalysis of the stratigraphic provenience of the lithic artifacts.

## Shape Change in the Sacroiliac Joint at the Emergence of *Homo*

Nichelle D. Reed *Evolutionary Anthropology, Duke University, USA*  
Steven E. Churchill, *Evolutionary Anthropology, Duke University, USA; and, Institute for Human Evolution, University of the Witwatersrand, SOUTH AFRICA*

The auricular surfaces of the os coxa are small relative to acetabular size in australopiths and relatively large in early *Homo* sp. This shift in relative joint size is likely related to the dramatic increase in body size beginning at the emergence of the genus *Homo*. Concurrent with this shift were changes to the posterior ilium, including an expansion of the retroauricular area and a greater protrusion of the iliac tuberosity, which suggest increased support by the sacroiliac ligaments. To further explore shape change in the sacroiliac area, we examined the auricular surface of the hominin ilium. We modeled the L-shaped joint surface as two perpendicular and overlapping rectangles—a larger inferior demifacet (ID), and a smaller superior demifacet (SD). Data were collected from original fossils and casts representing multiple species of *Australopithecus* and early and late Pleistocene *Homo*. Measurements were also taken on a sample of 102 modern humans from the Raymond Dart collection at the University of the Witwatersrand. Significant differences were detected between genera in relative sizes of ID and SD. Also, a shift occurs in the relationship between ID and SD area—australopiths have a positive correlation between the demifacets; modern humans have a negative correlation, such that as ID increases, SD decreases. Early *Homo* sp. fit with modern humans. These results may suggest a shift in bipedal kinematics at the emergence of *Homo*, altering the path of bodyweight through the sacroiliac joint. Alternately, these results may reflect body size—greater forces passing through the joint may require greater force damping at a somewhat more mobile sacroiliac joint (i.e., a more compliant joint surface). Reducing the relative size of SD may allow greater nutational/counternutational movement at the sacroiliac joint, which, when coupled with an enlarged posterior sacroiliac ligament may produce a more compliant, force damping system.

## PaleoCore: Data Integration for Paleoanthropology

Denné Reed, *Anthropology, University of Texas at Austin, USA*  
W. Andrew Barr, *Anthropology, University of Texas at Austin, USA*  
John Kappelman, *Anthropology, University of Texas at Austin, USA*  
Shannon McPherron, *Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
Tomislav Urban, *Texas Advanced Computing Center, University of Texas at Austin, USA*

Some of the most persistent and relevant questions in paleoanthropology—including the climatic, tectonic, and ecological factors influencing the origin of bipedality, megadonty, tool use, and speciation—are challenging to address with the data acquired by a single research project. These types of questions require a more coordinated approach to data collection, a more collaborative approach to data dissemination, and a more synthetic approach to data analysis than is currently achieved in paleoanthropology. The PaleoCore initiative aims to facilitate coordination, collaboration, and synthesis within paleoanthropology by promoting data standards, developing software tools to facilitate data collection and data management, and building a data portal through which researchers can query a federated network of paleoanthropological data providers. Towards this end, the PaleoCore project borrows and extends data standards and data infrastructure from biodiversity research (e.g., Darwin Core data standard: DwC; the Global Biodiversity Information Facility: GBIF) and archaeological research (e.g., the Digital Archaeological Record: Tdar; Online Cultural and Historical Research Environment: OCHRE). This paper outlines the goals, conceptual structure, and technological framework of the PaleoCore project and presents an analysis of the data structures used by more than 15 contributing projects. The analysis of these data structures reveals commonalities and differences in what data are recorded, how those data are recorded, and the software tools used in data

management. Based on this analysis we propose a provisional data ontology for paleoanthropology built from the bottom up by examining what data entities and concepts are most commonly recorded across projects.

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## Hominin Size, Stature, and Behavior Based on 1.5-Million-Year-Old Footprints from Ileret, Kenya

Brian G. Richmond, *Anthropology, The George Washington University, USA*  
 Kevin G. Hatala, *Anthropology, The George Washington University, USA*  
 Anna K. Behrensmeyer, *Paleobiology, Smithsonian Institution, USA*  
 René Bobe, *Anthropology, The George Washington University, USA*  
 David Braun, *Anthropology, The George Washington University, USA*  
 Heather L. Dingwall, *Human Evolutionary Biology, Harvard University, USA*  
 David J. Green, *Department of Anatomy, Midwestern University, USA*  
 Purity Kiura, *Archaeology Department, National Museum of Kenya, KENYA*  
 Brian Villmoare, *Department of Anthropology, The George Washington University, USA*  
 Roshna Wunderlich, *Department of Biology, James Madison University, USA*  
 John W.K. Harris, *Anthropology Department, Rutgers University, USA*

Fossilized footprints provide a unique window into the anatomy, behavior, and ecological setting of our extinct hominin relatives. Here we report our findings based on new excavations of the ‘upper layer’ footprint surface at the FwJj14E site near Ileret in the Koobi Fora Formation, Kenya, in 1.51–1.52 million-year-old sediments. We uncovered over 20 new hominin footprints and many animal prints in an area of approximately 15m<sup>2</sup> adjacent to our 2007 and 2008 excavations. The animal prints predominantly represent bovinds of various sizes, but also include prints of an extinct hippopotamus, indicating proximity to a body of water sufficiently large to support them. For our analyses of the anatomy and behavior of the printmakers, we used an experimental sample of footprints made at various speeds in reconstituted fossil footprint sediment by habitually unshod and minimally-shod adult Daasanach females (n=24) and males (n=24) from Ileret. The fossil footprint assemblage in the ‘upper layer’ at FwJj14E now includes several dozen hominin footprints representing at least five individuals. Most of the footprints are relatively large, comparable in size to footprints made by Daasanach adult males, and generally above the mean for footprints made by Daasanach females. Body mass and stature estimates based on the hominin prints depend on assumptions regarding whether the printmakers had foot proportions more similar to those of modern humans and *Homo ergaster*, or those of australopithecines. However, either assumption yields large mass and stature estimates, comparable to the predicted sizes of male *H. ergaster* or *Paranthropus boisei*. Notably, at least five hominin trails are oriented together in a significantly (p<0.05) different direction compared to the animal print orientations, and may represent a group of adult males traveling together. This footprint assemblage raises provocative questions about male behavior in early Pleistocene hominins.

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## Grotta Mario Bernardini Revisited: New Data on A Poorly Known Transitional Sequence in Southern Italy

Julien Riel-Salvatore, *Anthropology, University of Colorado Denver, USA*

This paper presents new information on the site of Grotta Mario Bernardini, near the modern-day city of Nardò in the region of Apulia (SE Italy). The site was excavated more than forty years ago, but beyond two excavation reports, little is known about the assemblages it yielded. This is problematic because the site also documents a sedimentary continuity between its Mousterian and Uluzzian levels, and because it is a rare inland site in the context of the Uluzzian of the Salento, which has mostly been recovered from what are today coastal settings. Based on new analyses of the site’s assemblages, this paper summarizes what is known about the site’s depositional history, presents the first complete stratigraphy, and details the behavioral strategies of the site’s Mousterian and Uluzzian occupants. Both in terms of mobility and raw material management, the hominins responsible for making the two technocomplexes show a great deal of overlap, suggesting that, in spite of techno-typological differences, they adapted to the challenges posed by the climatic vagaries of OIS 3 in remarkably similar ways. Given recent work positing a modern human authorship of the Uluzzian, these patterns are all the more provocative in showing a great deal of continuity between the Middle and Early Upper Paleolithic of the Salento peninsula, with implications for the Middle-upper Paleolithic transition at a broader scale. The paper concludes with a discussion of what this overlap might mean in terms of the behavioral similarities of Neanderthals and early European modern humans, bringing into question some of the limitations of the essentialism inherent in these debates.

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## New Excavations at the 2.6-Million-Year-Old OGS-7 Site, Gona, Ethiopia

Michael Rogers, *Department of Anthropology, Southern Connecticut State University, USA*  
 Sileshi Semaw, *Prehistoric Technology Research Group, Centro Nacional de Investigación sobre la Evolución Humana, SPAIN*  
 Dietrich Stout, *Department of Anthropology, Emory University, USA*  
 Naomi Levin, *Department of Earth and Planetary Studies, Johns Hopkins University, USA*

The OGS-7 (Ounda Gona South) site at Gona was discovered in February 2000 and first described in the *Journal of Human Evolution* in 2003. It was, and still is, the oldest *in situ* archaeological site known, at 2.6–2.55 Ma, with abundant stone artifacts and fossil fauna found in association. Other publications in 2005 and 2010 further elaborated upon aspects of the fauna, stone raw materials, and lithic technology exhibited by the OGS-7 assemblage. As important as the site is, the original archaeological assemblage came from less than three square meters of excavation. In 2010, we significantly expanded the excavation of the site into the hillside and recovered hundreds of additional artifacts and faunal specimens. Here we report on some preliminary observations of this new assemblage. In some respects, the additional material that we have recovered supports previous inferences we have made concerning, for example, raw material selectivity and probable carcass processing. The recovery of numerous small cores, though, in addition to several lithic refitting sets, allows us to describe in more detail the lithic technology exhibited by this assemblage. Further excavations are planned at the site, in addition to future work on lithic replication, use wear, and local paleoenvironmental reconstruction. Comparisons will be made with the other early sites at Gona, in particular the East Gona sites (EG-10, -12, -13, and -24) and OGS-6.

## The First Upper Paleolithic Human Remains from Belgium: Aurignacian, Gravettian, and Magdalenian Fossils at the “Troisième caverne” of Goyet

Hélène Rougier, *Department of Anthropology, California State University Northridge, USA*  
 Isabelle Crevecoeur, *CNRS, PACEA UMR 5199, Université Bordeaux 1, FRANCE*  
 Cédric Beauval, *Archéosphère, FRANCE*  
 Damien Flas, *FNRS, Département de Préhistoire, Université de Liège, BELGIUM*  
 Hervé Bocherens, *Fachbereich Geowissenschaften - Biogeologie, Universität Tübingen, GERMANY*  
 Christoph Wissing, *Fachbereich Geowissenschaften - Biogeologie, Universität Tübingen, GERMANY*  
 Mietje Germonpré, *Royal Belgian Institute of Natural Sciences, BELGIUM*  
 Patrick Semal, *Royal Belgian Institute of Natural Sciences, BELGIUM*  
 Johannes van der Plicht, *Centre for Isotope Research, Groningen University, THE NETHERLANDS*

There is ample evidence of human occupation across Northern Europe throughout various periods of the Upper Paleolithic. However, the biological characteristics of the Northern European Upper Paleolithic humans and their mortuary practices remain largely unknown because of a dearth of human fossils. In Belgium, although the presence of humans has been verified at multiple archeological sites, no Upper Paleolithic fossil has yet been identified. In this context, the recent discovery of Upper Paleolithic human remains at Goyet (Belgium) fills in an important chronological gap. The “Troisième caverne” of Goyet, excavated at the end of the 19th and early 20th century, yielded a rich archeological sequence ranging from the Middle and Upper Paleolithic to historical times. In 2008, we began documenting the Paleolithic occupations of the “Troisième caverne” by reassessing the collections from the site which heretofore had only been partially studied. The updated inventory of human remains was accomplished by conducting a detailed sorting of the paleontological collections in order to identify human remains that may have been overlooked thus far. As a result, the collections from the “Troisième caverne” now include nearly 200 human bones/bone fragments and isolated teeth that correspond to various materials from different periods. The morphometric study of the human specimens from Goyet, completed by direct radiocarbon dating and stable isotope analysis, shows that they represent two main samples—a series of Late Neandertal remains (Rougier et al. 2012) and a set of modern human specimens from three periods of the Upper Paleolithic, namely the Aurignacian, Gravettian, and Magdalenian. The latter include fragmentary elements from the cranial and infracranial skeleton. Interestingly, those from the Gravettian and Magdalenian present anthropogenic traces and ochre traces. We will discuss the importance of these new fossils in the context of the human population of Northern Europe during the Upper Paleolithic.

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### References Cited:

Rougier, H., Crevecoeur, I., Beauval, C., Bocherens, H., Flas, D., Germonpré, M., Semal, P., and van der Plicht, J. 2012. New data from an old site: Neandertals at Goyet (Belgium) and their mortuary behavior. *American Journal of Physical Anthropology* 147: 252–253.

## Early Microlithic Projectiles from Pinnacle Point, South Africa

Benjamin Schoville, *School of Human Evolution and Social Change, Arizona State University, USA*  
 Kyle Brown, *Department of Archaeology, University of Cape Town, SOUTH AFRICA*  
 Simen Oestmo, *School of Human Evolution and Social Change, Arizona State University, USA*

An occurrence of microlithic backed blades from Pinnacle Point site 5-6 (PP5-6) has recently been described by Brown et al. (2012) beginning ~71,000 years ago and lasting for ~11,000 years. Ethnographic analogies of backed blades from Holocene contexts suggest they functioned as projectile tips. To assess whether the PP5-6 backed blades were used as projectile armatures, patterns of impact macrofractures and edge damage from 194 experimentally reproduced backed pieces shot using a calibrated crossbow are compared

to the assemblage of pre-Howiesons Poort backed blades from Pinnacle Point. The location of each experimental shot on prey targets were combined into a prey body GIS model to construct a somatic distribution of point breakage probability. The experiment results suggest the PP5-6 backed blades would function effectively as projectile armatures in several hafting arrangements. Replicated backed tools were also subjected to long-term (~4 months) trampling in three different contexts to establish post-depositional breakage patterns on silcrete backed blades. The frequency of impact fractures and the frequency and distribution of edge damage on microlithic backed blades from PP5-6 are significantly different from trampling damage, and support the interpretation of the early backed blades as projectile tips.

#### References Cited:

Brown, K.S., Marean, C.W., Jacobs, Z., Schoville, B.J., Oestmo, S., Fisher, E.C., Bernatchez, J., Karkanas, P., and Matthews, T. 2012. An early and enduring advanced technology originating 71,000 years ago in South Africa. *Nature* 491, 590–593.

## Sympatric Primate Populations: Comparative Models for Evaluating Dental Morphological Variation in Early Hominins

Kes Schroer, *Center for the Advanced Study of Hominid Paleobiology, Department of Anthropology, The George Washington University, USA*  
Bernard Wood, *Center for the Advanced Study of Hominid Paleobiology, Department of Anthropology, The George Washington University, USA*

It is increasingly likely that two or more fossil hominin species lived sympatrically in East Africa between 2 and 1.5 million years ago. Ecological competition between sympatric hominin populations may have driven key evolutionary adaptations, including the different dental morphologies of *Paranthropus* and early *Homo*. Many modern primate populations live sympatrically and provide the opportunity to examine the morphological consequences of sympatric competition. Here, we investigated whether differences in mandibular postcanine morphology could be the result of sympatric competition in closely related primate populations. Our sample comprised seven mixed-sex groups of closely related primates, from both sympatric and solitary populations, in the National Museum of Natural History collection (i.e., African great apes, Asian apes, cebids, macaques, mangabeys, papionins, and tamarins, n=300+). We performed standard metric and 2D geometric morphometric analyses on sympatric and solitary populations of these taxa. Some features of the mandibular postcanine dentition (i.e., talonid contribution and the appearance of additional distal cusps) appear to differ more strongly between sympatric populations than between sympatric and solitary populations, suggesting that they could be an evolutionary response to resource competition. These results suggest that the differences in the post-canine dentitions of *Paranthropus* and early *Homo* may be the result of ecological character displacement in sympatric populations.

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## Mosaic Traits of the Human Mandible from Tam Pa Ling, Laos at 46 ka

Laura Shackelford, *Anthropology, University of Illinois at Urbana-Champaign, USA*  
Fabrice Demeter, *Department Homme Nature Societe, National Museum of Natural History, FRANCE*  
Anne-Marie Bacon, *Unité Propre de Recherche, Centre National de la Recherche Scientifique, FRANCE*  
Philippe Düringer, *Institut de Géologie, Université de Strasbourg, FRANCE*  
Kira Westaway, *Environment and Geography, Macquarie University, AUSTRALIA*  
Thongsa Sayavongkhamdy, *National Heritage, Ministry of Information and Culture, LAO PEOPLE'S DEMOCRATIC REPUBLIC*  
Jose Braga *Anthropobiology Laboratory, Université Paul-Sabatier, FRANCE*  
Jean-Luc Ponche, *Unité Mixte de Recherche, Centre National de la Recherche Scientifique, FRANCE*

Tam Pa Ling (TPL) is a cave site in northern Laos from which an early modern human (EMH) cranium was recently recovered (Demeter et al. 2012). This cranium (TPL 1) is fully modern in its anatomy with no archaic traits. The nearly complete mandible of a second individual (TPL 2) has been found in the same stratigraphic layer. Radiocarbon and luminescence dates of the surrounding sediments provide a minimum age of 46–51 ka for these fossils, and direct U-series dating of the cranium provides a maximum age of ca. 63 ka. These dates place the TPL specimens among the oldest, well-dated modern human fossils in eastern Asia. The mandible is small in overall dimensions, with a maximum length of 77.0mm and an estimated bicondylar breadth of 92–100mm. A majority of its characteristics are consistent with modern humans, most notably mental foramen position and the presence of a trigonum mentale (projecting tuber symphyseos and paired lateral tubercles). However, it also has archaic features, in particular the extreme bucco-lingual robusticity of the corpus at the mental foramen. The breadth of the mandibular corpus at the mental foramen of TPL 2 (16.2mm and 16.1mm for right and left sides, respectively) exceeds that of all EMH [East Asian EMH: 12.6±1.8mm (n=6), western EMH: 12.6±1.9mm (n=12)] and lies at the top of the range of variation for Neandertals [15.5±1.8mm (n=28)]. As such, geometric morphometric analyses and analyses of discrete traits are used to further investigate the morphology and associations of the TPL 2 mandible. The features demonstrated by TPL 2 suggest that the population in northern Laos around 50 ka demonstrated a mosaic of modern and archaic features or that two populations lived in this area within a relatively short time period.

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#### References Cited:

Demeter, F., Shackelford, L., Bacon, A.-M., Düringer, P., Westaway, K., Sayavongkhamdy, T., Braga, J., Sichanthongtip, P., Khamdalavong, P., Ponche, J.-L., Wang, H., Lundstrom, C., Patole-Edoumba, E., and Karpoff, A.-M. 2012. Anatomically modern human in Southeast Asia (Laos) by 46 ka. *Proceedings of the National Academy of Sciences, USA* 109, 14375–14380.

## Ostrich Eggshell Isotope Analysis: Results and Implications for Reconstructing Prehistoric Exchange Systems in the African Stone Age

Philip A. Slater, *Anthropology, University of Illinois, USA*  
 Stanley H. Ambrose, *Anthropology, University of Illinois, USA*  
 Marina V. Drigo, *Anthropology, University of Illinois, USA*  
 Polly Wiessner, *Anthropology, University of Utah, USA*

Ostrich eggshell (OES) beadwork was the most common gift among contemporary Kalahari San foragers until the 1980s. Their reciprocal gift-giving (hxaro) networks spanned up to 200km. Hxaro networks reinforced mutual rights of access to distant territories and resources. Enhanced information sharing regarding local environmental conditions and resource availability served to reduce risk in unpredictable environments. Carbon, oxygen, and strontium isotope analyses were conducted on five modern Kalahari San OES beadwork items (necklaces, headband) from five regions in Botswana to evaluate the potential of this analytical strategy for testing hypotheses of differences in prehistoric exchange network and home range sizes during the African Middle and Late Stone Ages. Our results show that strontium isotope ratios can differ significantly among geographical regions, and can identify beads added during the life history of a gift that has passed between hxaro network members. Carbon and oxygen isotopes can distinguish OES beads in a beadwork item from different eggshells within a geographic region, as defined by beads with the same strontium isotope ratios. Oxygen isotopes can provide environmental information such as surface water availability, temperature, and relative humidity. We conclude that isotopic analyses of ostrich eggshell beads provide a useful tool to investigate the scale of mobility, exchange, and cooperation during the evolution of modern human behavior. Cooperation and information sharing among dispersed hunter-gatherer groups may have provided a social safety net in times of resource unpredictability and scarcity, and increased chances of survival during the last Ice Age. Moreover, enhanced cooperation networks may have provided modern African humans with a competitive advantage over Eurasian hominids during their expansions out of Africa during the last ice age.

## The Phylogenetic Utility of Individual Cranial Bones in Cercopithecoïd Primates: Implications for Reconstructing Fossil Hominin and Non-Hominin Primate Phylogeny

Heather F. Smith, *Department of Anatomy, Midwestern University, USA*  
 Noreen von Cramon-Taubadel, *School of Anthropology & Conservation, University of Kent, UNITED KINGDOM*

The accurate reconstruction of phylogenetic relationships of extinct hominins and other fossil primate taxa is an essential step in the interpretation of the fossil record. This process is predicated upon the idea that craniodental morphology is informative about phylogeny, a concept which appears to be primarily well supported. Recent studies have suggested that the morphology of some particular cranial regions and individual cranial bones may be more reliable for reconstructing hominoid phylogeny than others, but it is unclear whether similar patterns characterize cercopithecoïd species. It is well documented that papionin primates can be plagued by allometric effects, such that the morphology of similarly sized taxa tends to converge among distantly related species. In order to determine whether cercopithecoïds display similar patterns of phylogenetic utility of individual bones as hominoids, 161 cranial landmarks from skulls of 365 primates representing fifteen cercopithecoïd species were digitized and compared statistically to their published molecular phylogenies. In the combined sex sample, the morphology of the entire cranium, maxilla, mandible, occipital, temporal, and zygomatic were all found to reliably reflect the phylogenetic relationships among species, while the frontal, parietal, and sphenoid were not. In the male-only sample, the entire cranium, maxilla, temporal, and zygomatic were congruent with the molecular phylogeny; while in females, the entire cranium, occipital, parietal, temporal, and zygomatic significantly reflected phylogeny. Overall, the lack of congruence in the cranial vault bones of males likely reflects the neurocranial cresting present in this sex. The consistently reliable entire cranium dataset suggests that landmark number may play a role, such that a greater quantity of cranial morphological information is preferable than less, regardless of the region of the skull from which it derives. These findings also highlight the importance of selecting taxonomically appropriate morphological regions when attempting to reconstruct taxonomy and phylogeny in fossil catarrhine primates.

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## The Discovery of an Upper Paleolithic Tool Type, *Lissoir*, in the Middle Paleolithic of Abri Peyrony and Pech de l'Azé I

Marie Soressi, *INRAP, FRANCE*  
 Shannon McPherron, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Michel Lenoir, *CNRS, UMR 5199 - PACEA, University of Bordeaux, FRANCE*  
 Tamara Dogandžić, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Paul Goldberg, *Archaeology Department, Boston University, USA*  
 Zenobia Jacobs, *Centre for Archaeological Science, University of Wollongong, AUSTRALIA*  
 Yolaine Maigrot, *CNRS, UMR 8215 - TRAJECTOIRES de la sédentarisation à l'État, FRANCE*  
 Naomi Martisius, *Department of Anthropology, University of California Davis, USA*

Christopher E. Miller, *Institute for Archaeological Sciences, University of Tübingen, GERMANY*  
 William Rendu, *CNRS, TRACES - UMR 5608, Université Toulouse-Le Mirail, FRANCE*  
 Michael P. Richards, *Department of Anthropology, The University of British Columbia, CANADA*  
 Matthew M. Skinner, *Department of Anthropology, University College London, UNITED KINGDOM*  
 Teresa E. Steele, *Department of Anthropology, University of California Davis, USA*  
 Sahra Talamo, *Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, GERMANY*  
 Jean-Pierre Texier, *CNRS, Université Bordeaux 1, FRANCE*

Specialized bone technology first appears in Africa and is widespread in Europe after the arrival of modern humans with the beginning of the Upper Paleolithic. Modern humans shaped bone by grinding and polishing to produce standardized or so-called formal tools that were used for specific functions. Examples of Neandertal bone tools do exist; however, most of these were made through percussion to mimic existing stone tools such as handaxes, scrapers, and denticulates. Standardized bone tools in forms distinct from stone tools and shaped by grinding and polishing occur in the Châtelperronian and Uluzzian, but, a) whether Neandertals made these assemblage types is debated; and, furthermore, b) their late date means that Neandertals could have been influenced by modern humans already in Europe. Other examples with earlier dates are disputed. Recent excavations at the Middle Paleolithic sites of Abri Peyrony and Pech de l'Azé I resulted in the discovery of four *lissoir* fragments coming from three, separate and radiometrically dated deposits. The two sites are 35km apart and both contain Mousterian of Acheulian Tradition industries. Neither our excavations nor multiple prior excavations have detected overlying Châtelperronian or later industries that could have been the source of these artifacts. *Lissoir* are a formal, standardized bone tool type, made by grinding and polishing, interpreted as being used to prepare hides, and previously only associated with modern humans. The Abri Peyrony and Pech de l'Azé I bones are the earliest evidence of specialized bone tools associated with Neandertals, and they move the debate over whether Neandertals independently invented aspects of modern human culture to before the time of population replacement.

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## New Discoveries at Old Sites: The Legacy of J.D. Clark in Karonga, Malawi

Jessica Thompson, *School of Social Science, Archaeology Program, The University of Queensland, AUSTRALIA*  
 Andrew Zipkin, *Center for the Advanced Study of Hominid Paleobiology, Department of Anthropology, The George Washington University, USA*  
 Sheila Nightingale, *Graduate Center, City University of New York, USA*  
 David Wright, *Department of Archaeology and Art History, Seoul National University, SOUTH KOREA*  
 Jeong-Heon Choi, *Division of Earth and Environmental Science, Korea Basic Science Institute, SOUTH KOREA*  
 Alex Mackay, *School of Archaeology and Anthropology, Australian National University, AUSTRALIA*  
 Menno Welling, *African Heritage: Research and Consultancy, MALAWI*  
 Elizabeth Gomani-Chindebvu, *Malawi Ministry of Tourism, Wildlife, and Culture, MALAWI*

In the 1960s and 1970s, J.D. Clark and his students located several significant archaeological sites in Malawi, including an entire landscape of Middle Stone Age (MSA) materials in the northernmost district of Karonga. One of these, referred to by Clark as Chaminade 1A, yielded an assemblage of over 25,000 stone artifacts and several specimens of worked ochre from an *in situ* deposit. However, the site has never been absolutely dated, the ochre and stone artifact assemblages have not been thoroughly analyzed, and in the years since Clark's excavation, its exact location has been lost. In 2012, a site named Bruce was discovered in Karonga that had several outstanding qualities: 1) more than 18 pieces of red pigment were found on the modern land surface, with nearly half of the assemblage displaying clear human modification; 2) the raw material diversity shows a high proportion of less common stone types, such as silcrete and chert, in addition to the quartz and quartzite that otherwise typify the area's assemblages; and, 3) Levallois technology dominates the surface assemblage and artifacts are often found to be heavily reduced, despite immediate abundance of raw materials. Historical research and local informants from Karonga suggest that Bruce is actually the same site as Chaminade 1A. Considering the importance of ochre in recent MSA research and the large quantity of artifacts recovered by Clark from *in situ* deposits at Chaminade 1A, finding the site again has strong historical and scientific significance. The site shows repeated, intensive MSA occupation of a floodplain environment in which a range of raw materials and lithic reduction strategies were used. This new work updates Clark's legacy in Karonga, integrating it into a larger picture of the range of human adaptation during the MSA of central Africa.

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## Middle Stone Age Site Use along the Shinfa River in NW Ethiopia

Lawrence Todd, *Anthropology, University of Texas Austin, USA*  
 John Kappelman, *Anthropology, University of Texas Austin, USA*  
 Marvin Kay, *Anthropology, University of Arkansas, USA*  
 Brett Nachman, *Anthropology, University of Texas Austin, USA*  
 Nicholas Rosenau, *Earth Sciences, Southern Methodist University, USA*  
 Neil Tabor, *Earth Sciences, Southern Methodist University, USA*

Integrated analysis of a series of surface sites, test excavations, and a block excavation area at a single MSA locality provides an opportunity to examine Middle Stone Age activity structure at multiple spatial scales. We present here new data for MSA humans living in open air sites on the lowland slope of Ethiopia's northwestern plateau along the upper reaches of the Shinfa River, one of the Blue Nile's tributaries. At the site level of investigation (sub meter spatial scale), distributional patterns of thermally altered lithic (e.g., potlids, crazing, color changes, and thermal fractures) suggest localized high intensity burning, which may represent hearth-based activities. Item size classes and refitting provide evidence for stone tool manufacture and/or refurbishing adjacent to the most

distinctive of these possible hearth areas. At the regional level (hectare spatial scale), patterns in raw material frequencies, item size, use-wear attributes and reduction stage characteristics point to variation in landuse patterns. The majority of raw materials were obtained from the nearby gravel bars of an ancient river, with the open air sites situated in close proximity to waterholes that apparently lasted throughout the dry season.

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## Applying Evolutionary Development to Lithic Technology: The Generative Entrenchment of Blade Core Technology

Gilbert Tostevin, *Anthropology, University of Minnesota, USA*

Our understanding of how stone tool technology has changed through time has benefited from ideas derived from many diverse disciplines. Yet there has been little discussion of how the new perspectives from evolutionary development might provide new ways to understand lithic technology. This paper advances an hypothesis for how blade core technology was at specific times subject to generative entrenchment. Generative entrenchment is the process that causes the evolutionary retention of elements that: 1) appear early in ontogeny; and, 2) causally shape the morphology or function of ontogenetically-later elements (Wimsatt 1986, 2001). Mutations are less likely to be adaptive when affecting generatively entrenched elements because of the larger ramifications on downstream dependencies. Wimsatt and Griesemer (2007) have explored generative entrenchment in recent cultural evolution but there has been little investigation of its role in deep time. This paper explores the articulations between generative entrenchment and lithic technology. Through the derivation of model predictions from design theory (Carr 1995), as well as the costs/benefits of blade core technology (Bar-Yosef and Kuhn 1999; Eren et al. 2008), the paper predicts that downstream dependencies of blade core technology appear strongest when blade blank morphology significantly determines the standardization (*sensu* Monnier 2006: 77) of the functional morphology of the retouched tool kit for hafting and/or piercing. Through a survey of blade technologies from the Middle Pleistocene through the Holocene, generative entrenchment thus appears to contribute to the evolutionary retention of blade core technology throughout the Upper Paleolithic and Neolithic, but not within most of the “precocious” Early Middle Paleolithic blade technologies, nor within the Epipaleolithic/Mesolithic. This perspective offers new alternative hypotheses for the interpretation of Shea’s (2012) new Modes A-I, the modeling of Pleistocene technology (Andersson 2011; Premo and Kuhn 2010), and the patterning of Middle Paleolithic prepared core technologies (Delagnes and Rendu. 2011).

### References Cited:

- Andersson, C. 2011. Paleolithic Punctuations and Equilibria: Did Retention Rather Than Invention Limit Technological Evolution? *PaleoAnthropology* 2011: 243–259.
- Bar-Yosef, O. and S.L. Kuhn. 1999. The Big Deal About Blades: Laminar Technologies and Human Evolution. *American Anthropologist* 101(2): 322–338.
- Carr, C. 1995. A Unified Middle-Range Theory of Artifact Design. In *Style, Society, and Person: Archaeological and Ethnological Perspectives*, C. Carr and J. Neitzel (eds.), pp. 171–258. Plenum Press, New York.
- Delagnes, A. and W. Rendu. 2011. Shifts in Neandertal Mobility, Technology and Subsistence Strategies in Western France. *Journal of Archaeological Science* 38: 1771–1783.
- Eren, M. I., Greenspan, A., and Sampson, C. G. 2008. Are Upper Paleolithic Blade Cores More Productive than Middle Paleolithic Discoidal Cores? A Replication Experiment. *Journal of Human Evolution* 55: 952–961.
- Monnier, G. 2006. Testing Retouched Flake Tool Standardization During the Middle Paleolithic: Patterns and Implications. In *Transitions Before the Transition: Evolution and Stability in the Middle Paleolithic and Middle Stone Age*, S. Kuhn and E. Hovers (eds.), pp. 57–83. Springer, New York.
- Premo, L.S. and S.L. Kuhn. 2010. Modeling Effects of Local Extinctions on Culture Change and Diversity in the Paleolithic. *PLoS ONE* 5(12): 15582.
- 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* 12 February 2012. DOI 10.1007/s10816-012-9128-5.
- Wimsatt, W. 1986. Developmental Constraints, Generative Entrenchment, and the Innate Acquired Distinction. In *Integrating Scientific Disciplines*, P.W. Bechtel (ed.), pp. 185–208. Martinus-Nijhoff, Dordrecht.
- Wimsatt, W. 2001. Generative Entrenchment and the Developmental Systems Approach to Evolutionary Processes. In *Cycles of Contingency: Developmental Systems and Evolution*, S. Oyama, R. Gray, and P. Griffiths, (eds.), pp 219–237. MIT Press, Cambridge.
- Wimsatt, W.C., and J.R. Griesemer. 2007. Reproducing Entrenchments to Scaffold Culture: The Central Role of Development in Cultural Evolution. In *Integrating Evolution and Development: From Theory to Practice*, R. Sansome and R. Brandon (eds.), pp. 228–323. MIT Press, Cambridge.

## Pleistocene Archaeology and Paleoenvironments of the Lake Victoria Basin in Kenya

Christian Tryon, *Anthropology, New York University, USA*

J. Tyler Faith, *School of Social Science, University of Queensland, AUSTRALIA*

Daniel Peppe, *Geology, Baylor University, USA*

Nick Blegen, *Anthropology, University of Connecticut, USA*

Emily Beverly, *Geology, Baylor University, USA*

David Patterson, *Center for the Advanced Study of Hominid Paleobiology, The George Washington University, USA*

Zenobia Jacobs, *Center for Archaeological Science, University of Wollongong, AUSTRALIA*

Renaud Joannes-Boyau, *Southern Cross Geoscience, AUSTRALIA*

David Fox, *Geology, University of Minnesota, USA*

Sheila Nightingale, *Anthropology, City University of New York, USA*

Myra Laird, *Anthropology, New York University, USA*

Kirsten Jenkins, *Anthropology, University of Minnesota, USA*

Cara Roure Johnson, *Anthropology, University of Connecticut, USA*

Niki Garrett, *Anthropology, University of Minnesota, USA*

Lake Victoria is the largest body of water in Africa and is surrounded by a diverse mosaic of forest and grassland habitats. These

habitats changed with expansions and contractions of the lake throughout the Pleistocene. This dynamic environment provides the context for highly variable but still poorly documented archaeological and paleontological records of the Lake Victoria basin. We emphasize here our ongoing investigations of Late Pleistocene Middle Stone Age (MSA) archaeological sites and paleoenvironments on Rusinga and Mfangano islands, and introduce Karungu, located on the Kenyan shores of Lake Victoria. Karungu is a large (>25km<sup>2</sup>) site complex with multiple exposures of Miocene, Pleistocene, and Holocene sediments first described in the early 20th century by F. Oswald and the Archdeacon W.E. Owen. In addition to archival research, our renewed investigations at Karungu have focused on >9-m-thick fluvial and alluvial sediments with multiple well-developed vertisols and correlative tephra deposits. The sediments contain Acheulian and MSA artifacts as well as abundant, well-preserved, and taxonomically diverse macro- and micro-mammalian fossil fauna. Artifact typological as well as biochronological evidence suggests Middle and Late Pleistocene ages for many of the Karungu deposits, periods in eastern Africa for which sites with associated lithic and faunal remains are rare. The fauna from Rusinga, Mfangano, and Karungu indicate drier and more open paleoenvironmental conditions than today and the presence of non-analog animal communities. Paleoenvironmental and chronological foundations established at Rusinga, Mfangano, and Karungu provide essential data to understand the behavioral variability manifest in the Acheulian, Sangoan, Lupemban, and MSA sites dating prior to and during the origin and expansion of *Homo sapiens*.

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## Neandertal Neonatal Brain Size Estimating: Validity of DeSilva and Lesnik (2008) Models and New Proposals

Petr Tuma, *Anthropology and Human Genetics, Charles University, CZECH REPUBLIC*  
Jaroslav Bruzek, *PACEA-A3P, UMR 5199 CNRS, Université Bordeaux 1, FRANCE*

Knowing the range of variations of brain size in newborns is important for the obstetrical aspects of the Neandertal biology. Fossil remains from the neonatal period are rare and fragmentary though, therefore necessitating other means for the reconstruction of the neonatal brain size. A possible solution to this problem is modeling of the brain size at birth. In our study, seven anthropoid species were chosen based on data kindly provided by Jeremy DeSilva, detailing newborn and adult brain sizes. Neandertal brain volume data (n=23) were compiled from a dataset described by Holloway et al. (2004). Brain size of recent populations has been collected from 566 individuals of both sexes ranging from 18 to 50 years of age at the Department of Forensic Medicine, Garches (France). For the prediction of the Neandertal neonatal brain size, we used regressions and resampling techniques. In the first step we tested the DeSilva and Lesnik (2008) regressions which led to an overestimation of the human neonatal brain size. We propose new regressions and estimate the mean Neandertal neonatal brain size between 408 and 410cm<sup>3</sup>, and between 394 and 396cm<sup>3</sup> for the modern human newborns. These results are consistent with CT-based virtual reconstructions of Neandertal newborns.

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## The Prehistory of Right-Handedness and Functional Brain Lateralization for Stone Tool-Making

Natalie Uomini, *Archaeology, Classics & Egyptology, University of Liverpool, UNITED KINGDOM*  
Georg Meyer, *Psychology, University of Liverpool, UNITED KINGDOM*

Complex tool-making and language are two areas that set humans apart from other animals. The popular theory that both skills co-evolved in the human lineage rests on the hypothesis that both skills share underlying processes and neural systems, but there is little empirical evidence for these. Direct evidence that both skills draw on common brain areas or result in common brain activation patterns would provide compelling support for this argument. Language and stone tool-making have so far only been studied separately using a range of neuroimaging techniques and diverse paradigms. Here we present the first ever study of brain activation to directly compare active Acheulean tool-making and language. We show highly correlated cerebral blood flow lateralization patterns (hemodynamics) in the initial 10 seconds of task execution, measured by functional transcranial Doppler ultrasound (fTCD). Our findings add a further piece of evidence to support the co-evolution of stone tool-making and language, supporting a shared neural substrate for both human specializations. Our results are consistent with the proposal of a common network for complex action planning in language and tool production. Our study also demonstrates that fTCD is a promising novel methodology for studying real-time brain activation during prehistoric stone tool production.

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## Spatial Analysis of *Australopithecus sediba* Fossils in 3D and Taphonomic Implications

Aurore Val, *University of the Witwatersrand, Faculty of Science, School of Geosciences, Bernard Price Institute for Palaeontological Research, SOUTH AFRICA; and, Laboratoire PACEA, UMR 5199 CNRS, Université Bordeaux 1, FRANCE*  
Paul Dirks, *James Cook University, School of Earth and Environmental Sciences, AUSTRALIA; and, School of Geosciences, University of the Witwatersrand, Johannesburg, SOUTH*

## AFRICA

Lucinda Backwell, *University of the Witwatersrand, Faculty of Science, School of Geosciences, Bernard Price Institute for Palaeontological Research, SOUTH AFRICA*

Francesco d'Errico, *University Bordeaux 1, Laboratoire PACEA, UMR 5199 CNRS, FRANCE*

Lee Berger, *University of the Witwatersrand, Institute for Human Evolution, SOUTH AFRICA*

A innovative combination of Computed Tomography (CT), micro-CT scanning, and virtual reconstruction techniques was applied to create an accurate 3D rendering of the original position of the two near-complete and well-preserved *Australopithecus sediba* skeletons (MH1 and MH2), within the sediments of the Plio-Pleistocene Malapa cave (Gauteng Province, South Africa). This 3D model will guide future excavations, and served conducting a detailed spatial analysis of the hominin fossils in 3D to address taphonomic questions regarding the accumulation and fossilization processes. The spatial distribution and orientation of the hominin remains within the deposit illustrate a very low dispersal of the bones, indicative of a short time between death and burial, due to the action of a debris flow and possible mummification.

## Proximal Femoral Morphology of Berg Aukas in the Context of Global Variation Among Modern Humans

Christopher S. Walker, *Evolutionary Anthropology, Duke University, USA*

Shilpa Sridhar, *Evolutionary Anthropology, Duke University, USA*

Steven E. Churchill, *Evolutionary Anthropology, Duke University, USA; and, Institute for Human Evolution, University of the Witwatersrand, SOUTH AFRICA*

The presumably Middle Pleistocene proximal femur from Berg Aukas, Namibia, is notable for its large femoral head, low neck-shaft angle, and thick diaphyseal cortex, the combination of which differentiate the specimen from *Australopithecus*, early *Homo*, and modern humans (Grine et al. 1995). Though the femoral diaphyseal robusticity of the Berg Aukas femur is typical for an equatorial archaic human, the femoral head is as large as that of a Neandertal, and the neck-shaft angle is extraordinarily low for any hominin (Trinkaus et al. 1999). This suite of features has been explained as the result of high levels of lower limb loading during development, which prompted a decrease in neck-shaft angle and increase in femoral head size due to high hip joint reaction forces, and moderate adult lower limb loading as evidenced by average (for an archaic human) levels of femoral diaphyseal robusticity (Trinkaus et al. 1999). If this interpretation is correct, neck-shaft angle and femoral head diameter would be expected to be highly correlated with each other, but not necessarily correlated with measures of femoral robusticity within human populations. Using a global sample of 3,410 individuals from 101 groups (Gilligan 2010), neck-shaft angle and femoral head diameter were found to have no correlation ( $r^2=0.002$ ), whereas a positive correlation was found between femoral head diameter and femoral midshaft robusticity ( $r^2=0.61$ ). Consequently, it seems unlikely that high childhood activity levels and moderate adult activity levels alone can explain the unique morphology of the Berg Aukas femur.

### References Cited:

Gilligan, I. 2010. Prehistoric clothing and ice age climates: Cold stress, Neanderthal extinction, and the emergence of modern human behavior. PhD Thesis, Australian National University.

Grine, F.E., Jungers, W.L., Tobias, P.V., and Pearson, O.M. 1995. Fossil *Homo* femur from Berg Aukas, Northern Namibia. *American Journal of Physical Anthropology* 97, 151–185.

Trinkaus, E., Ruff, C.B., and Conroy, G.C. 1999. The anomalous archaic *Homo* femur from Berg Aukas, Namibia: A biomechanical assessment. *American Journal of Physical Anthropology* 110, 379–391.

## Late Pleistocene Craniofacial Variation at the Eastern Frontier

Steven Wang, *Anthropology, The Graduate School and University Center of the City University of New York, USA*

In our discussion of modern human emergence and dispersal in eastern Eurasia, the fossil remains from Zhoukoudian Shandong have played a continuous and focal role since their discovery in the 1930s. Valuable and diagnostic as these crania may be, however, the assemblage represents only a single and restricted vestige; therefore, it can only provide a partial glimpse into the Late Pleistocene hominin saga at the eastern frontier. This study continues the preliminary results presented at the 2009 Paleoanthropology Society meeting and reexamines the shape morphology and regional characteristics of numerous less well-known early modern crania from East Asia (EA), including Lijiang, Liujiang, Ziyang, and Minatogawa. Analyses were carried out on landmark and discrete character data collected on well-preserved African, Eurasian, Australasian, and American fossil *H. sapiens* (n=22), the Neandertals (n=5), and a geographically dispersed pool of recent human sample (n=555). The landmark data were broken into three subsets, allowing a more meticulous perusal of the facial, the temporal bone, and the vault morphology. The character analysis assessed the frequency of occurrence of numerous purported regional continuity traits. Morphometric results indicate that not all EA early moderns shared the same kind of cranial shape affinity with respect to recent populations. Rather, geography seems to play a role in the sense that northern EA fossils show more shape similarities to Amerindian groups, while the southern EA fossils show more shape similarities to recent populations in Southeast Asia. Moreover, shape affinities between the EA fossils in question and those from Africa, Europe, and Australasia also vary greatly, with the Upper Cave showing close ties to Europe. Results from the character analysis suggest that many of the discrete traits do not show higher than expected occurrence in their respective, purported region. Taken together, cranial heterogeneity in Late Pleistocene Asia and regional continuity will be discussed.

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## Oldowan and Acheulean Tool Manufacture Upper Limb Strategies

Erin Marie Williams, *Center for the Advanced Study of Hominid Paleobiology, The George Washington University, USA*

Adam D Gordon, *Anthropology, University at Albany--SUNY, USA*

Vance R. Powell, *Anthropology, The George Washington University, USA*

Alison S Brooks, *Center for the Advanced Study of Hominid Paleobiology, The George Washington University, USA*

Brian G Richmond, *Center for the Advanced Study of Hominid Paleobiology, The George Washington University, USA*

The transition from the Oldowan to the Acheulean marks a major behavioral shift in human evolution, likely involving a combination of cognitive and anatomical changes, as well as their intersection-motor control. Here we apply high-speed 3-D motion capture technology to investigate the upper limb motion strategies used during the Oldowan and the Acheulean traditions to test the null hypothesis that they share a common upper limb motion strategy. Data were captured from eight experienced subjects using a VICON Nexus motion capture system (200 Hz). Each subject produced two Oldowan choppers and two Acheulean handaxes in cortex-free raw English flint (standard Oldowan swings=237, standard Acheulean swings=378, Acheulean trimming-swings=193). Across knappers, we did not find evidence of consistent differences in gross upper limb motions between the two traditions (e.g., peak joint angles, joint excursion ranges). Further, during both Oldowan and Acheulean knapping sequences knappers relied on the “dart-thrower’s arc” and the same modified proximal-to-distal joint sequence. However, trimming-swings, used to shape the tool during Acheulean handaxe production, were performed with a unique set of joint motions compared with those used during the standard-swings of both tool traditions. In addition, trimming-swing strike forces were significantly lower compared with the strike force of standard-swings. We also found evidence of an overall reduction in strike force in five of eight knappers during Acheulean knapping sequences compared with Oldowan ones. These results demonstrate that Oldowan and Acheulean reduction sequences share a common upper limb joint motion strategy when using standard-swings; there is some evidence, however, that they differ in force production. The biomechanical uniqueness of trimming-swing motions and force reduction speak to the use of motion inhibition and restraint for the production of Acheulean handaxes compared with that of Oldowan choppers.

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## Life History in Human Evolution: A Baboon Model

Christopher Williams, *Archaeology, University of Sheffield, UNITED KINGDOM*

Reconstructing the life history of early hominins is fundamental in establishing how and when humans evolved their distinctive life history profile. The large number of cercopithecoid fossils recovered from East and South African Plio-Pleistocene hominin-bearing sites indicate that baboons and hominins co-existed in the same environments for 2–3 million years. Consequently, baboons are frequently used as a primate model upon which to study aspects of early hominin palaeobiology. This study presents a baboon model of life history evolution, inferred from dental development, which is used to elucidate the evolution of life history, growth, and maturation in the human lineage. Tooth mineralization and emergence data are provided from a cross-sectional skeletal sample (n=173) of extant wild-shot baboons (*Papio hamadryas* subspecies) and a sample of fossil baboons (n=63) attributed to species of *Parapapio* and *Papio*. Tooth mineralization status was scored from CT scans using an eight-stage system adapted from Demirjian et al. (1973) and tooth emergence was scored as either present or absent. The basic sequences of tooth mineralization and emergence are presented, together with the location and frequency of sequence variations. Sex differences and differences between jaws are also examined. Variations in tooth mineralization sequences distinguish the extant and fossil samples. *Parapapio* exhibits reduced canine sex dimorphism in comparison with extant *Papio*. Tooth emergence sequences are conservative among the extant and fossil baboons and appear to follow a general papionin pattern. Dental development in baboons has changed little over the last ~2.5 Ma. Plasticity in diet, behavior and ecology, in the absence of a consistent selective pressure, has enabled baboons to adapt to environmental and ecological changes within a generalist life history framework. The baboon model of life history evolution lies in stark contrast to the significant morphological, behavioral, and life history evolution observed in the human lineage.

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## Notes on the Chinese Upper Paleolithic

Xiaohong Wu, *School of Archaeology & Museology, Peking University, CHINA*

Youping Wang, *School of Archaeology & Museology, Peking University, CHINA*

Ofer Bar-Yosef, *Anthropology, Harvard University, USA*

The clearest expressions of the Upper Paleolithic in western Eurasia are the lithic blade industries often accompanied by bone, antler and ivory objects, and body ornaments. A similar phenomenon concerning the lithics in mainland China would be the emergence of microblade industries. Cultural elements of the Eurasian Upper Paleolithic, such as bone artifacts and ornaments, were already found in Upper Cave Zhoukoudian dated to ca. 30 Ka. These are associated with a core and flake industry and skulls of modern humans. The lessons are that surface surveys where only lithics are preserved cannot be identified as of Upper Paleolithic age, and dated core and

flake assemblages in cave sites face similar difficulties. Hence, when we try to recognize the boundary between the Middle and Upper Paleolithic in China, a techno-typological shift is harder to establish than in western Eurasia. These ambiguities, including stratigraphic issues, lack of sound radiocarbon chronology, and the description of lithic assemblages requires additional systematic research. The main distribution of microblade sites is in north China as this complex was dated to as early as 28 Ka cal BP and lasted through the early Holocene. In south China, no similar industries were uncovered and reported. This absence is not related to the nature of raw material sources as one can find suitable flint, chalcedony, and chert for making microliths in many locations. The accepted Upper Paleolithic industries from ca. 30 Ka are of the 'core and flake' type and were eventually replaced by cobble tools associated with bone and antler objects. From the late LGM through the Terminal Pleistocene these cave assemblages are associated with pottery. Our presentation will include several series of dates with the corresponding industries as illustrations to the challenges posed by the research of the Late Paleolithic in China.

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## Form and Function of the Forefoot During Vertical Climbing in Chimpanzees (*Pan troglodytes*)

Roshna E. Wunderlich, *Department of Biology, James Madison University, USA*  
 Sara B. Ischinger, *Department of Biology, James Madison University, USA*

Upright bipedalism is a hallmark of hominin locomotion, however, debates continue regarding the extent of arboreal locomotion and the nature of bipedalism in early hominins. Pedal form and function play a prominent role in these debates, as the foot is the element contacting the substrate. Comparative evidence suggesting a relationship between metatarsal robusticity, shape, and torsion and habitual pedal posture and loading environment has been used to ascribe pedal function to numerous new fossil metatarsals. Numerous authors have demonstrated a distinctive arrangement of metatarsal torsion in apes in which the first metatarsal is everted and the 2nd–5th (especially 2nd/3rd) metatarsals are inverted. However, little evidence exists to relate pedal form in hominoids to function on various substrates. We examined forefoot morphology (joint size and shape, robusticity, length) in 261 hominoids (*Pan*, *Gorilla*, *Hylobates*, *Pongo*, *Homo*) and plantar pressure distribution in two chimpanzees (*P. troglodytes*) during vertical climbing compared to ground and horizontal pole locomotion. Plantar pressure was collected with a flexible Pliance mat (11 Hz, Novel GmbH, Munich) that was attached to a vertical pole. Peak pressures and pressure-time integrals were analyzed in the heel, midfoot, metatarsals 1, 2/3, 4/5, and phalanges. Chimpanzees and other hominoids are characterized by long and robust 2nd/3rd compared to 4th/5th metatarsals. While climbing vertically, chimpanzees exhibit the lowest metatarsal pressures on metatarsals 4/5 early in stance. Load is transferred to the medial side of the foot where metatarsals 1 and 2/3 exhibit similarly high pressure at 60% of stance. Metatarsals 2/3 experience the highest ( $p < 0.05$ ) peak pressure at the end of stance (toe-off), relatively higher than during ground or horizontal pole locomotion. These patterns are consistent with interpretations of metatarsal torsion in *Pan* and also suggest that the robusticity of the medial forefoot in hominoids is related to pedal adaptations for climbing.

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